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Volume 25 BULLETIN Article 4

Biology of the White Crappie *in Illinois*

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Printed by Authority of the State of Illinois

URBANA, ILLINOIS
August 1951

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This paper is a contribution from the Section of Aquatic Biology.

(20440—4M—12-50)

CONTENTS

The frontispiece shows fishermen congregated along a riprapped approach to one of the highway bridges across Lake Decatur. (Photograph from Decatur *Herald-Review*.)

Biology of the White Crappie *in Illinois*

)ONALD F. HANSEN

THE white crappie, *Pomoxis annularis* Rafinesque, and the black crappie, *Pomoxis nigro-maculatus* Le Sueur), are among the most characteristic and abundant fishes of the lakes nd streams of Illinois. They are popular ith Illinois anglers and are generally nked with the better food fishes of the ate. Both species have been used exnsively for stocking artificial lakes of arious sizes.

This paper is based largely on white rappie studies carried on by the writer at ake Decatur, Macon County, Illinois, uring the period beginning in late Noember, 1935, and ending in early Decemer, 1939. Most of the fish for the Lake)ecatur studies were caught in hoop nets nat were operated at 1- to 2-month inrvals at all seasons of the year.

Year-round collecting at Lake Decatur rovided material on the white crappie for etermination of spawning time, length f the annual growing period, seasonal uctuations in plumpness, time of year of igh natural mortality, and date of anulus formation. In addition, this collectng brought to light seasonal variations in x ratios and evidence that the hoop net less efficient for capture of crappies in arm weather than in cold weather.

Pronounced yearly differences were obrved in time of annulus formation (Hansen 1937), length of growing peod, size and age distribution, and rate of rowth of the white crappie.

Included with information from Lake)ecatur is some additional information bout crappies that was obtained from other places in the state as a result of field investigations by various members of the Natural History Survey staff during an 18-year period beginning in 1927.

ACKNOWLEDGMENTS

Most of the crappie information from waters of the state other than Lake Decatur was collected during fisheries investigations carried on by Dr. David H. Thompson while head of the Section of Aquatic Biology of the Natural History Survey. His unpublished observations on length, weight, sex, lymphocystis disease, day and night rates of hoop-net capture, and angling represent important contributions to the paper.

Nearly everyone who worked in the Section of Aquatic Biology of the Natural History Survey in the 18-year period beginning in June, 1927, had a part in the collecting of field data. Francis D. Hunt undoubtedly measured more fish and gathered more scale samples from all parts of the state than any other person. Dr. Louis A. Krumholz helped with all the Lake Decatur collecting from late 1938 through 1939.

During the period of intensive field work at Lake Decatur, Sam A. Parr, then employed by the city of Decatur as lake inspector, and Ely Mooreland, caretaker at Faries Park, furnished information about the lake, helped to provide places to work during bad weather, and sometimes assisted with netting operations.

Photographs of Lake Decatur were lent by the Decatur *Herald-Review*.

The entire manuscript was read by Dr. George W. Bennett, Dr. Elizabeth B. Chase, and James S. Ayars, and parts were read by Agnes C. Hansen and Dr. William C. Starrett. Each offered valuable criticism.

I am especially indebted to Dr. Bennett and Dr. Thompson for what they have contributed through discussion.

METHODS AND TECHNIQUES

Because the white crappies used in this study were taken from a number of different waters, by different collectors, and over a considerable period of time, several methods of collection and techniques of study are represented.

Collections

With the exception of two collections from hook-and-line catches, all of the fish taken from Lake Decatur for this study were trapped in 1-inch-mesh hoop nets, that is, fykes or wing nets, each having a pot or rear compartment of 1-inch mesh (square measure). Most of the fish from other waters also were taken with 1-inch mesh hoop nets, but some fish were taken with hoop nets and seines of other mesh sizes, with hook and line, with rotenone poison, and by draining lakes. The methods of capture are specified throughout the paper in connection with discussion of the data. The 1-inch-mesh hoop nets retain white crappies as small as 4 inches total length. The fish of this length are usually a little over a year old. No effort was made at Lake Decatur to sample fish of lengths less than 4 inches.

Hoop nets of the type used at Decatur and at most other collecting stations are made of netting stretched over a series of wooden hoops to form a cylinder 10 or 12 feet long and usually 3½ to 4½ feet in diameter. Each net is divided into two compartments. A funnel-shaped entrance leads fish into a front compartment; a second funnel leads them into a rear compartment or pot. A "fingerthroat" is used at the inner funnel opening to help prevent reverse movement, that is, prevent escape of fish from the pot. Wings 10 feet long are attached on either side of the hoop at the open end and serve to guide fish into the trap. Ordinarily a separate lead net, 40 to 60 feet long, is used with each hoop net. Two poles, one at the outer end of each of the wings, and a third, at the end of the pot, are pushed into the lake or stream bottom to hold the net in the "set" position. The lead net is secured in a similar manner. The mesh of the lead, wings, and front compartment of the hoop net is 1½ inches square, while the mesh of the rear compartment, or pot, is 1 inch square. Designations of mesh size of hoop nets mentioned in this paper refer to the mesh of the pot.

At Lake Decatur and elsewhere, the hoop nets were set usually with a few inches of net standing out of water. For example, a 3½-foot-diameter net was set where the water was about 3 feet deep. The period between setting the nets and emptying them varied ordinarily from 1 to 3 days.

Two winter hoop-net collections were made at Lake Decatur after the formation of heavy ice over most of the lake. In January, 1938, nets were set in a place that was kept open by warm water from the A. E. Staley plant. This water, which flowed into the lake from a ditch just above Nelson Park, fig. 1, originally was pumped from the lake into a cooling system within the plant, where in the cooling operation it was warmed; it was then returned to the lake. In January, 1939, the nets were set in an open area between the old and new Illinois Terminal Railroad bridges, three-fourths of a mile below Faries Park, fig. 1, on the upper west side of Lake Decatur. Neither at Lake Decatur nor elsewhere were nets operated under the ice.

Length Measurements

Most white crappies included in this study were measured in inches, to the nearest tenth of an inch, on calibrated measuring boards. The 1933 collection of crappies from Senachwine Lake was measured in millimeters.

Standard length was the basis of measurement before January, 1939, and total length after that date. Total length was measured from the tip of the lower jaw to the end of the longest ray of the tail with the mouth of the fish closed and

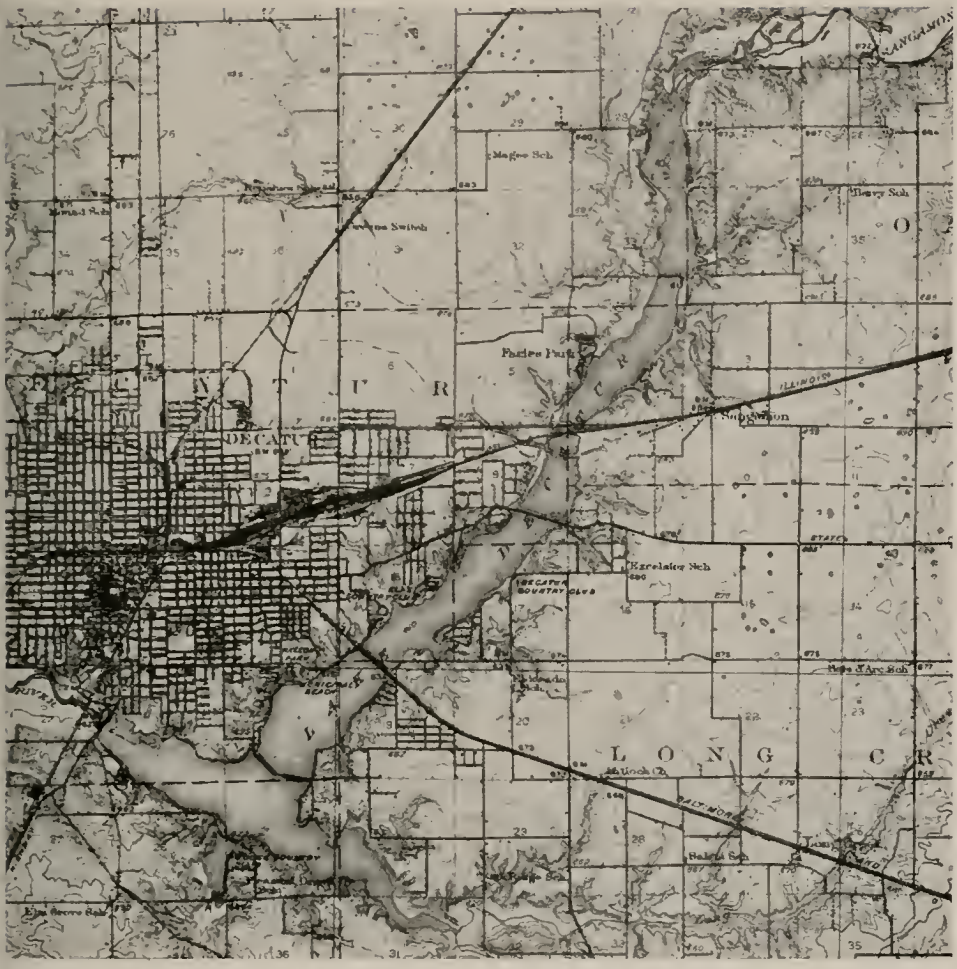

Fig. 1.—Lake Decatur and connecting streams, from the U.S. Coast and Geodetic Survey Decatur Quadrangle.

with the rays of the tail laid parallel rather than fanned. Standard length was measured from the tip of the lower jaw to the crease at the base of the tail. This crease marks the anterior end of caudal rays and is a little forward of the last scales on the tail. The standard-length measurements were converted into total lengths for this paper, except that standard lengths were used in computing coefficients of condition and in discussing length-weight relationships.

Length classes are designated in this paper by class center. Three different class intervals were used: one-half inch, 1 inch, and 1½ inches. Fish were assigned to length classes as illustrated by the following examples from the class intervals:

One-half-inch class interval: 5-inch class (4.8–5.2 inches); 5½-inch class (5.3–5.7 inches).

1-inch class interval: 5-inch class (4.6–5.5 inches); 6-inch class (5.6–6.5 inches).

1½-inch class interval: 6-inch class (5.3–6.7 inches); 7½-inch class (6.8–8.2 inches).

Weight Measurements

Lake Decatur crappies were weighed on a Chatillon dietetic spring balance of 1,000 grams capacity. The dial of the scale was marked at 4-gram intervals, and readings were made to the nearest 4-gram mark.

The fish were iced if necessary to prevent their spoiling when more than a day was required to handle large collections. The 1933 Senachwine Lake crappies 2 inches or more in length were weighed to the nearest one-tenth gram; those less than 2 inches long were weighed to the nearest one-hundredth gram. The crappies from Horseshoe Lake and Craborchard Lake were weighed to the nearest one-hundredth pound. The Senachwine Lake crappies were carefully wiped to remove excess water before being weighed. This practice was not followed elsewhere.

During the first several hours after death it is possible that fish, if kept in water, gain slightly in weight. Repeated weighings of a white crappie that before death had a total length of 8.5 inches and a weight of 148 grams showed after death a weight increase of 2 grams in 4 hours and 6 grams in 7 hours. This fish was kept in ice water between weighings.

There may also be a slight decrease in body length after death which, together with the increase in dead weight over live weight, would tend to give a dead fish a higher coefficient of condition than a live one. Whether this weight change is typical or not, it probably had only a minor effect on the conclusions reached from the length-weight study of the Lake Decatur fish, since measuring and weighing usually were completed within 4 to 5 hours after the fish were removed from the nets.

Identification of Sexes

Differences in breeding coloration were not usually relied upon as a method of distinguishing sex. This method was used for a single collection (June 2–5, 1947) at Lake Decatur, and was also used by Dr. David H. Thompson for his observations on sex in the Illinois River valley in 1942. As shown by tests, however, this method is not entirely reliable, and the rule at Lake Decatur was to dissect a fish when neither eggs nor sperm could be squeezed from the genital opening.

Scale Collections

Thirty to 50 scales were removed from the left side of each fish in the region between the dorsal spines and the lateral line. At Lake Decatur, to avoid the accidental mixing of scale samples, scaling tools were rinsed after scales had been taken from each fish.

Scale Analyses

Fish ages were determined by counting the number of annual rings on the scales. About half the scale examinations were made with a low-power, binocular, dissecting microscope on uncleaned, unmounted, dry scales. The other examinations were made from the projected images of cleaned scales mounted on slides in glycerine jelly or Farrant's medium.

Interpretation of the growth rings is discussed in the section that deals with age and growth. Age readings were made on practically all white crappie scale material collected in Illinois for the Natural History Survey up to January, 1939, and on some material collected later.

With the following exceptions, age determinations are those of the author: Lynn Hutchens read the scales collected at North Lake, November, 1931, Lake Chautauqua, November, 1936, and Weldon Springs Lake, July, 1936; William Hoyer (National Youth Administration) read the scales collected at Senachwine Lake, August–November, 1933. Hutchens read the Lake Decatur scales collected in March–August, 1937; most of the June–August collections of that year were reexamined by the author.

Sampling Procedure

At Lake Decatur, and usually elsewhere, data from hoop nets were obtained from entire catches; no attempt was made to select fish of any particular size. However, about one-third of the scale material from the rest of the state was collected during a Natural History Survey tagging experiment in which only specimens longer than 6 inches were used. Also, some of the fish which the Survey tagged were caught by commercial fishermen, and field notes did not always show whether these fishermen had furnished their entire catches or not. It can be assumed that anglers, from whom some of the data were obtained, did not in all cases keep all of their small fish.

Periods of Study

The over-all period covered by the Lake Decatur collections was late November, 1935, to early December, 1939. Length measurements and scale samples were obtained from all Lake Decatur collections. Weighing was begun in early April, 1936, and continued through 1939. Sex, whether male or female, was recorded at two periods, late May, 1936, through July, 1937, and November, 1938, through December, 1939; records were kept of ripe fish taken at spawning time in 1936, 1937, and 1939.

Age readings and the study of length-weight relationships were terminated with the collection of January 9, 1939. The later 1939 collections were used in the study of size distribution, sex ratio, and seasonal variations in rate of hoop-net capture.

Study Limitations

In certain phases of the Lake Decatur study, analyses were made on the basis of broods. Fish hatched in the same calendar year constituted a brood. Because the brood assignments in collections made in May and June, 1936, at the time of annulus formation were thought to be particularly open to question, the collections taken during those months were not used in making certain analyses.

In general, the study of broods was limited to those from which fish were taken in greatest abundance over the longest periods. The older broods, which disappeared from net catches shortly after the beginning of observations (broods hatched in 1930–1932), were omitted from most analyses.

Some entire collections, or parts of collections, were omitted from consideration when a breakdown of data into several categories resulted in poor representation. Two collection dates that appear in some of the tables, one in May, 1937, and one in May, 1939, were based on observations of fish caught by anglers. These dates are, therefore, not represented in the tables showing rate of catch in hoop nets.

CRAPPIE DISTRIBUTION

Both the white crappie and the black crappie were reported by Forbes & Richardson (1920) as occurring in lakes and streams throughout Illinois. The black crappie was reported as the more common species in the glacial lakes of northeastern Illinois, and the white crappie as the more common in the creeks of the state.

Relative abundance of the two species tends to vary sharply in hoop-net sampling, which has provided most of the recent data on distribution of crappies in this state. Although no assurance can be given that net sampling has been adequate in all the localities sampled, it is believed that the relative abundance of the two species has been correctly represented for the various categories of lakes and streams discussed.

In all Illinois water-supply reservoirs that have been intensively studied, white crappies were found to be more abundant than blacks. The whites made up at least 95 per cent, and the blacks 5 per cent or less, of the large number of crappies caught with hoop nets in three reservoirs, Decatur, Craborchard, and Pana; the whites were the only crappies caught in Lake Springfield. The hoop-net observations at Lake Springfield and Lake Decatur were verified by observations of the hook-and-line catch in these reservoirs.

The predominance of white crappies in these reservoirs may be due to one or several factors, three of which are suggested here: (1) a possibly greater suitability of the reservoir habitat for white crappies, (2) a probable predominance of white crappies in feeder streams, (3) a possibly heavier artificial stocking of white crappies.

In most ponds studied by the Natural History Survey, white crappies were found to outnumber blacks. In a poison census of 22 ponds of 12 acres each or smaller (Bennett 1943), both species were found in 14 ponds, only whites were found in 3, and only blacks in 3. In the 14 ponds in which both species were found, whites predominated by weight in 10, blacks in 1; only traces of the two species were found in 3 ponds.

One possible explanation of the predominance of whites in most of the ponds may be the more common occurrence of these fish in "creeks" (Forbes & Richardson 1920), the source of many of the fish used in stocking ponds. The green

Fig. 2.—Public bathing beach at Nelson Park, Lake Decatur, in July, 1943. (Photograph from Decatur *Herald-Review*.)

sunfish, a typical creek species, was found in all but 1 of the 22 ponds censused by Bennett. Another possible explanation may be a predominance of whites in the natural stocking that takes place from feeder streams or from nearby streams that overflow in times of high water. Still another explanation may be a greater suitability of the pond habitat for the whites.

In bottomland lakes bordering the Illinois River, the predominance of one species over the other is not striking. Both species seem to be abundant. Of the crappies taken in a 1942 hoop-net survey of the Illinois River and its bottomland lakes, 56 per cent of the total crappie catch from the lakes were blacks. In collections from most of these lakes, the blacks predominated. In collections from the only two bottomland lakes sampled along the Ohio River, the whites predominated.

In the main channel of the Illinois River, the predominance of the blacks is more pronounced than in the bordering lakes. Of the crappies taken from the main channel in the 1942 survey mentioned above, 73 per cent were blacks. Of the crappies taken in 1944 and 1946 hoop-net surveys of Mississippi River navigation pools (pools 12–26) extending from Dubuque, Iowa, downstream to Winfield, Missouri, approximately two-thirds were whites.

Data on the following rivers in which both species of crappies occur may not give a true picture of relative abundance, since, in spite of intensive netting operations, rather small numbers of crappies were caught. Records show that more blacks than whites were taken in the Des Plaines River, but that more whites than blacks were caught in the Rock, Kaskaskia (Luce 1933), and Ohio Rivers.

Hubbs & Lagler (1947) stated that the black crappie is less common than the white crappie in silty waters. The relation between siltiness and the predominance of one species over the other is not clearly apparent in the Illinois waters studied. The black crappie, for instance, predominates in some of the silty waters of the Illinois River valley as well as in comparatively non-silty glacial lakes of the northeastern corner of the state.

DESCRIPTION OF LAKE DECATUR

Lake Decatur, fig. 1, is a city water supply reservoir made in 1922 by damming the Sangamon River at Decatur, 75 miles below its source. While the lake was built primarily to meet the home and

industrial water needs of a manufacturing center, recreational uses that include fishing, swimming, and boating are encouraged by the city, figs. 2 and 3.

The lake is 10.4 miles long and varies from one-fourth to three-fourths of a mile in width; its original area was 2,805 acres. In 1936 Glymph & Jones (1937) found a depth of 15 feet at the dam and a depth of 6 feet midway in the lake between upper and lower ends.

Oxygen analyses made on July 29,

Fig. 3.—Sail boating on Lake Decatur; the *Aloha* in 1939. (Photograph from Decatur *Herald-Review*.)

1932, by D. J. O'Donnell, then of the Natural History Survey, indicated a fairly uniform distribution of dissolved oxygen from surface to bottom.

Ice covers most of the lake for about 2 or 2½ months of the year. Some dates of ice departure were February 23, 1936, February 28, 1939, and March 13, 1940.

Glymph & Jones (1937) showed that during the first 14 years of impoundment, 1922–1936, sediment had been laid down on the bottom to a depth that averaged 1 foot near the dam and increased gradually to 2 feet in the upper portion of the lake. Deposits of sediment from 3 to 7 feet thick were measured in the old river channel in the main part of the lake. The river channel above the lake had remained quite clear of deposits as a result of the scouring action of floods. The accumulation of sediment in Lake Decatur had resulted in a loss of 14 per cent of the original storage capacity of the reservoir, or 1 per cent per year. According to Brown, Stall, & De Turk (1947), the rate of loss increased to 1.2 per cent per year during the period 1936–1946. In *The Story of a Lake*, Walker (1949) has given a popular account of the silting of Lake Decatur.

The turbid condition of Lake Decatur probably accounted for the scarcity of aquatic plants at the time of this study. While in some places there were extensive beds of water primrose (*Jussiaea* sp.), arrowhead (*Sagittaria* sp.), and cattail (*Typha* sp.), most of the shore line was bare of emergent aquatic plants. No plants of strictly underwater habit were recorded, although they may have been present in some areas.

The bottom fauna of this lake was studied by Gersbacher (1937) and the plankton by Eddy (1932).

A list of the species of fish and numbers of each kind caught in Lake Decatur with hoop nets from April, 1936, through September, 1937, is shown in table 1. The species composition of anglers' catches at Lake Decatur as observed in partial censuses is shown in two tables: table 2, representing counts by the writer of the catches of 71 fishermen who were using

Table 1.—Species and numbers of fish caught in 1-inch mesh hoop nets at Lake Decatur during the period April, 1936, through September, 1937.

Species*	Number of Fish Caught
Shortnose gar, *Lepisosteus platostomus* Rafinesque	6
Gizzard shad, *Dorosoma cepedianum* (Le Sueur)	614
Buffalofishes, *Megastomatobus cyprinella* (Valenciennes), *Ictiobus niger* (Rafinesque), and *I. bubalus* (Rafinesque)	268
Carpsucker, *Carpiodes* sp.	292
Spotted sucker, *Minytrema melanops* (Rafinesque)	1
White sucker, *Catostomus commersonnii* (Lacépède)	3
Redhorse, *Moxostoma* sp.	119
Carp, *Cyprinus carpio* Linnaeus	141
Golden shiner, *Notemigonus crysoleucas* (Mitchill)	3
Channel catfish, *Ictalurus lacustris* (Walbaum)	150
Yellow bullhead, *Ameiurus natalis* (Le Sueur)	1
Black bullhead, *Ameiurus melas* (Rafinesque)	160
Flathead catfish, *Pilodictis olivaris* (Rafinesque)	4
Pike, *Esox lucius* Linnaeus	2
White crappie, *Pomoxis annularis* Rafinesque	2,531
Black crappie, *Pomoxis nigro-maculatus* (Le Sueur)	123
Warmouth, *Chaenobryttus coronarius* (Bartram)	1
Green sunfish, *Lepomis cyanellus* Rafinesque	3
Bluegill, *Lepomis macrochirus* Rafinesque	97
Pumpkinseed, *Lepomis gibbosus* (Linnaeus)	8
Largemouth black bass, *Micropterus salmoides* (Lacépède)	29
Yellow perch, *Perca flavescens* (Mitchill)	22
Yellow bass, *Morone interrupta* Gill	880
Freshwater drum, *Aplodinotus grunniens* Rafinesque	391

* Common and scientific names from American Fisheries Society Special Publication No. 1 (Anonymous 1948).

Table 2.—Species and numbers of fish caught with live minnows by 71 bank fishermen at Lake Decatur, as shown by stringer counts in May, 1937, and May, 1939.

SPECIES	NUMBER OF FISH CAUGHT MAY 16, 1937, BY 13 FISHERMEN	NUMBER OF FISH CAUGHT MAY 17–20, 1939, BY 58 FISHERMEN
Channel catfish	—	5
Flathead catfish	1	1
White crappie	86	102
Black crappie	1	—
Green sunfish	2	—
Sunfish*	—	1
Largemouth bass	1	—
Yellow bass	1	—
Freshwater drum	4	3
Total	*96*	*112*

* Kind not specified.

Table 3.—Kinds and numbers of fish caught with earthworms by Harold Taylor in year-round fishing at Lake Decatur; 179 trips during the years 1934–1938.

KIND OF FISH*	NUMBER OF FISH CAUGHT
Buffalo	3
Silver carp	1
Sucker and redhorse	9
Carp	169
Channel cat	113
Bullhead	1,089
Flathead cat	2
Crappie	11
Sunfish	160
Yellow bass	245
Sheepshead	690
Total	*2,492*
Total weight, 1,012 pounds	

* Names of fish are those used by Harold Taylor in his records. The sheepshead is the same fish as the freshwater drum.

live minnows for bait, and table 3, showing the catch of one fisherman, Harold Taylor, in the course of 179 trips (mostly at the head of the lake), in year-round fishing over a 5-year period. While Taylor's personal record shows that a variety of species could be caught in the lake, there was relatively little fishing for any kind but crappies. Many Decatur residents and many people from surrounding towns took advantage of the crappie fishing. Stringers examined at Lake Decatur in 1937 and 1939, table 2, as well as those examined in 1935, contained many more white crappies than black crappies.

SPORT FISHING

At Lake Decatur, fishermen interviewed during the period of field work reported that they caught white crappies principally from March 1 to June 1 and that midsummer fishing was a waste of time for most of them. In 1935, however, crappies continued to bite well until mid-July. In some Illinois localities crappie fishing is less confined to the spring months than at Lake Decatur and in a few is continued during most of the year.

At Lake Chautauqua, the most productive crappie fishing in 1941 and 1942 came in May and June (Hansen 1942), while the best fishing in 1944 came between mid-July and mid-September. A 12-year fishing record for Rinaker Lake, Macoupin County, studied by Dr. David H. Thompson (unpublished) showed that June, July, and October were the best months for crappie fishing at that lake, with July somewhat better than the other 2 months. Illinois crappies sometimes bite well in midwinter as shown by excellent catches made in January of some years in open water areas at the edge of Lake Chautauqua. The numbers and kinds of crappies caught have not been recorded and may have included both species.

At Lake Decatur, during the period of this study, crappie fishermen generally fished on the approaches to the several railroad and highway bridges that cross the lake. Here most of them sat on the broken concrete riprap and fished with cane poles and live minnows, frontispiece. At this lake, fishermen did little crappie fishing from the natural lake shore or from boats.

In most other parts of Illinois, as at Lake Decatur, still fishing with live minnows is doubtless more common than casting, trolling, or fly fishing. At Rinaker Lake, however, the preferred method is trolling with either live or dead minnows. According to Evermann & Clark (1920), trolling was at one time a favorite method of taking crappies at Cedar Lake, Indiana.

Large crappies are occasionally caught on bass plugs. Worms and artificial fly-rod baits are effective at times. Larry Simandle, who, while living at Canton, often fished for crappies with artificial baits at Lake Chautauqua, recommended the following fly-rod baits: Paulson's Pilk (weedless) with pork rind, Pflueger Pilot flies, Pflueger Pippin Wobbler, and four patterns in trout flies—white miller, red ibis, royal coachman, brown hackle.

Robert Page Lincoln, outdoor writer, is credited with describing a trolling lure that he considered as good a crappie bait as a live minnow. This bait consisted of a strip of freshly caught fish measuring a little over an inch in length (with skin on one side) placed on a hook below a one-half to three-quarter inch gold-plated spinner; a 4-foot gut leader was used between the spinner shaft and line.

A few fishermen employed special methods and were successful in catching crappies at Lake Decatur throughout the summer. The method described by E. F. Zehnpfund involved wading near the bank where the water was 1 or 2 feet deep and slowly bobbing a minnow up and down near projecting sticks and brush. This fisherman emphasized that where obvious cover, such as brush, was scarce he did not overlook the most isolated projecting weed stalk as a possible place to catch a fish.

Robert Witke used a different method for catching crappies in the summer: A stake was driven into the lake bottom with 2 or 3 feet left projecting above the water. A line with hook attached was fastened to the top of the stake so that a live minnow placed on the hook was able to swim only in a small area close to the surface. The crappies then came to the surface to take the bait.

Mr. and Mrs. O. D. Zook of Springfield have fished for white crappies in Lake Springfield for many years and have established for themselves a local reputation as expert crappie fishermen. While most fishermen at Lake Springfield, like those at Lake Decatur, have difficulty in catching crappies in midsummer, Mr. and Mrs. Zook have usually been able to catch these fish from early spring to late fall by varying their fishing methods with season of the year. They use artificial lures as well as minnows. Mr. Zook, who specializes in artificial fly-rod baits, has had success with a small spinner and white fly combination and with various all-metal baits (Pflueger Pippin Wobbler, Arbogast Tin Liz, South Bend Trix Oreno) and with homemade baits patterned after the baits named. He is of the opinion that these metal baits are improved by replacing their metal "flippers" with a strip of thin white rubber, one-eighth inch wide by 1 inch long, tapered to a point. He has used artificial lures mainly in his spring and fall fishing.

The Zooks fish with minnows in shallow water in the spring but in deep water in the summer; in early spring from a bank where the water is only 1 or 2 feet deep, and later, in May and June, from a boat dock where the water is 6 to 8 feet deep. When the weather becomes hot and they can no longer catch crappies from the boat dock, they fish with minnows from a boat in a submerged creek channel at a depth of 10 to 15 feet. These two fishermen believe that locating concentrations of fish is one aspect of successful crappie fishing and making the crappies bite is another. Mrs. Zook has written as follows:

"Sometimes a foot in depth or a foot to one side or the other makes a difference of an empty or full stringer. I bob the minnow up and down—move it sideways through the water—change spots if it is only a few inches. I keep the minnow moving constantly. If the crappies don't hit almost as soon as the minnow is dropped in, you may as well move around and aggravate them until they do hit. I know it is possible to do that. In the spring I saw a 14-inch crappie in the boat house; it took me 25 minutes to catch him. If ever a crappie was aggravated, he was. I dangled a minnow all over him—it was interesting how he would knock the minnow out of his way."

The Zooks believe that crappies like to stay in and around brush and snags, and that these fish sometimes show a preference for small minnows over large minnows. Two Peoria Lake fishermen were sure that large-size crappies, kind not mentioned, preferred small minnows while medium-size crappies were not so particular about the size of the minnows.

In Lake Springfield, where most of the crappies are small, the Zooks usually made

their best catches of large crappies during the first 3 weeks in May and continued to make good catches of small crappies for several weeks longer.

Many fishermen keep quite small crappies when large ones are scarce. Of 32 stringers containing white crappies examined at Lake Springfield, May 22–25, 1941, 30 stringers contained white crappies that measured 7 inches or less, total length. A grouping of the 296 white crappies found on the 32 stringers into half-inch length classes showed that 66 per cent fell in the 5½- to 7-inch classes, 27 per cent in the 7½- and 8-inch classes, and 7 per cent in the 8½-inch class or above.

NET SAMPLING

In hoop-net fishing for crappies, variations have been found in the rates of capture at different seasons; also, in the

Table 4.—Seasonal variation in rate of capture of white crappies in 1-inch-mesh hoop nets in Lake Decatur.

Date of Collection	Sampling Station	Number of Nets	Net-Days	Number of White Crappies Caught	Number per Net-Day
1935					
Nov. 22	Faries Park	2–3	3	78	26
1936					
April 3	Faries Park	3	16	326	21
May 4–6	Faries Park	1	4	75	19
May 29–June 4	Faries Park and Big Creek	1	7	100	14
June 22	Faries Park	1	3	15	5
July 3–5	Big Creek	1	6	48	8
July 31–Aug. 3	Big Creek	1	5	73	15
Sept. 8–14	Big Creek	1	6	29	5
Sept. 22	Nelson Park Beach	2	4	61	15
Oct. 24–27	Faries Park	3	12	240	20
Dec. 21	Staley's Outlet	3	15	297	20
1937					
March 1–4	Faries Park	2	16	666	41
April 24	Faries Park	2	6	117	20
June 3–5	Faries Park	3	12	233	19
June 24	Faries Park	3	9	140	16
July 10–16	Faries Park	3	27	94	3
Aug. 6–14	Big Creek, Lost Bridge, and Beverly Heights	3	30	74	2
Sept. 22	Faries Park	3	6	218	37
Nov. 3	Faries Park	3	6	170	28
1938					
Jan. 17–24	Staley's outlet	3	17	18	1
March 14	Faries Park	3	9	266	30
May 28	Faries Park	4	8	108	14
July 1–14	Faries Park	3	9	42	4
Aug. 25	Faries Park	7	14	79	6
Oct. 6	Faries Park	4	10	67	7
Nov. 4–11	Faries Park	3–4	20	75	4
1939					
Jan. 9	¾ mile below Faries Park	4	12	159	13
March 24	Faries Park	4	16	315	20
May 3	Faries Park	4	8	148	19
May 29	Faries Park	4	12	122	10
June 20	(Not recorded)	6	12	136	11
July 13–17	Faries Park and ½ mile below	4	15	302	20
Aug. 24	Faries Park	4	12	82	7
Oct. 16	Nelson Park Beach	3	6	270	45
Dec. 11	Nelson Park Beach	6	24	829	35

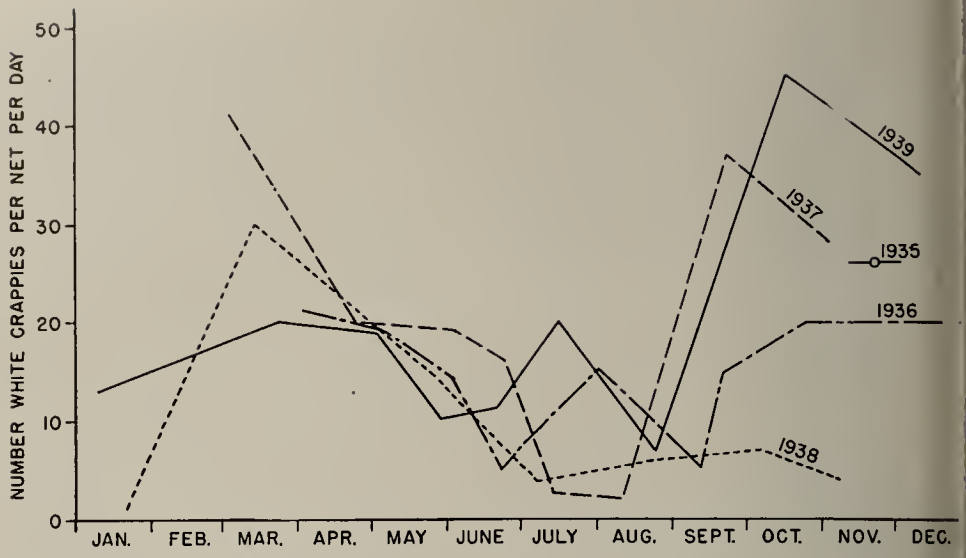

Fig. 4.—Seasonal variation in the rate of capture of Lake Decatur white crappies in inch-mesh hoop nets in the years 1935–1939.

rates of capture of the two species at different times of day and from week to week.

Seasonal Variations

Ordinarily the Lake Decatur crappies were more readily trapped in fall, winter, and spring than in summer. They were least readily trapped from about mid-July to late September, table 4 and fig. 4. The more noticeable departures from this trend include comparatively good catches in July, 1936, and July, 1939, and comparatively poor catches in January, October, and November, 1938. To some extent the wide fluctuations in catch rate at Lake Decatur may have resulted from lack of uniformity in sampling procedure. Thus, number of nets in use, number of days of operation, manner of setting, and occasional shifting of the nets from the Faries Park area to other places on the lake were all variables that might have affected the catch. All of the sampling in 1937 and 1938 was done in the Faries Park area, with the exception of the August collection in 1937 and the January collection in 1938. Summer mortality of crappies, discussed in the section "Size and Age Distribution," may have contributed to the poor summer net fishing at Lake Decatur.

Hoop-net sampling at Lake Glendale, Pope County (unpublished data), has shown similar seasonal trends in catchability of the bluegill, *Lepomis macrochirus,* and the largemouth bass, *Micropterus salmoides.* Lake Glendale netting operations were carried on at specified stations, and sets were duplicated the year round.

According to statements of commercial fishermen on the Illinois River, carp and buffalo also are trapped with difficulty in the summer months.

Species Variations

Differences in behavior patterns of black crappies and white crappies are suggested by differences in rates of capture of the two species.

Catch Rates at Night and During Day.—A hoop-netting experiment (results unpublished) carried on by Dr. David H. Thompson in 1931 at Meredosia Bay, one of the large bottomland lakes along the Illinois River, suggests the presence of a daily rhythm in crappie movement. The hoop nets were raised, emptied, and reset twice daily at the approximate hours of 6 A.M. and 5 P.M. on 25 different days during the period of June 24 through August 17. Nets were set within about 150 feet of the

Table 5.—Catches of white crappies and black crappies in morning and evening raises of 1-inch-mesh hoop nets. Data from an unpublished study made by David H. Thompson at Meredosia Bay, near Meredosia, Illinois, summer of 1931.*

Date	Number of Nets	Number of White Crappies		Number of Black Crappies	
		6 A.M. Raise	5 P.M. Raise	6 A.M. Raise	5 P.M. Raise
June 24	10	373	196	527	183
June 30	6	127	46	169	25
July 1	6	138	51	247	27
July 7	6	136	90	103	14
8	6	79	63	74	14
9	6	84	64	31	28
10	6	44	84	10	3
July 14	4	132	58	256	64
15	4	182	45	418	16
16	4	162	42	332	11
17	4	221	50	364	21
July 21	4	130	40	821	51
22	4	259	98	1,311	158
23	4	120	69	529	56
24	4	316	56	1,002	63
July 28	4	45	17	83	19
29	4	25	6	73	14
July 31	6	140	35	297	41
Aug. 4	4	49	9	32	4
Aug. 11	4	38	65	11	30
12	4	57	46	37	9
13	4	68	77	63	15
14	4	64	46	32	10
17	6	74	23	64	3
Total	—	*3,063*	*1,376*	*6,886*	*879*

* Horizontal broken lines set off raises made in the same locations. Fishing was carried on in nine different parts of the lake during this experiment.

Table 6.—Rates of capture of white crappies and black crappies in short periods of fishing with 1-inch-mesh hoop nets. Data from an unpublished study made by David H. Thompson at Meredosia Bay, near Meredosia, Illinois, summer of 1931.

Net Station	Period of Fishing	Total Net-Days	Number of Fish		Catch per Net-Day	
			White Crappies	Black Crappies	White Crappies	Black Crappies
A	June 24	10	569	710	60	71
B	June 30–July 1	12	362	468	30	39
C	July 7–10	24	644	277	27	12
D	July 14–17	16	892	1,482	56	93
E	July 21–24	16	1,088	3,991	68	249
F	July 28–29	8	93	189	12	24
G	July 31	6	175	338	29	56
H	Aug. 4	4	58	36	15	9
I	Aug. 11–17	22	1,134	274	52	12

shore where the water was about the depth of the nets or shallower. The location of the nets was changed at weekly intervals.

The experiment showed that except on a few dates both species entered the nets in larger numbers between the hours of 5 P.M. and 6 A.M. than in the remaining hours of the day, table 5. During the whole experiment the raises at 6 A.M. yielded approximately twice as many whites and eight times as many blacks as the raises at 5 P.M. It is not known whether fish in the 6 A.M. raises had entered the nets during the hours of total darkness. It is presumed, however, that many had.

The following are offered as explanations of the larger catches at night: (1) The fish possibly were more vulnerable to capture during the hours of darkness when less able to avoid the nets or see their way of escape if once captured. (2) They possibly were more concentrated near shore during all or part of the night period (this explanation implying in-shore and off-shore movement, perhaps for purposes of feeding). (3) They possibly were more actively engaged in swimming at night than during the day. It is not believed that the longer night period, 13 hours as compared with 11 hours during the day, could fully account for the differences observed.

A striking difference between white crappies and black crappies in the degree of expression of this day-night catchability was found. Morning raises yielded more blacks than whites, evening raises more whites than blacks, table 5.

Catch Rates by Weekly Periods.—Additional evidence that white crappies have different behavior patterns from those of black crappies is shown by comparing catch totals by 1-week periods. In tables 6 and 7, catch totals of white crappies and of black crappies are shown for hoop-net fishing carried on at Meredosia Bay in 1931 and at Lake Chautauqua at various times in the period 1931–1945. These tables show that in both lakes the ratios of numbers of these two species often fluctuated widely from week to week, sometimes in spite of large catches of both species. It must be emphasized, however, that the netting sites were changed at frequent intervals at both Meredosia Bay and Lake Chautauqua and

Table 7.—Fluctuations in numbers of white crappies and black crappies collected during short periods of fishing with 1-inch-mesh hoop nets at Lake Chautauqua, near Havana, Illinois, 1931–1945.

Date of Collection*	Number of White Crappies	Number of Black Crappies
1931		
June 11–13	48	205
1934		
April 4–May 4	6	1,303
1935		
Nov. 14–25	5	34
1936		
Feb. 12–April 12	3	18
Sept. 1–6	134	45
Sept. 7–13	455	241
Sept. 14–20	117	119
Sept. 21–27	158	141
Sept. 28–Oct. 4	465	179
Oct. 5–11	160	305
Oct. 12–18	208	465
Oct. 26–Nov. 1	24	145
1937		
March 29–April 5	113	665
April 26–30	74	134
May 4–5	17	21
1940		
March 21–27	1,803	673
March 29–April 4	3,281	2,150
April 5–11	516	935
April 12–18	1,444	412
April 19–25	992	846
April 26–May 2	281	307
May 10–16	618	373
May 17–23	2,772	1,267
May 24–30	279	196
1941		
April 7–14	1,177	1,068
May 29–June 4	24	264
Nov. 9–10	57	160
1942		
May 4–14	586	597
July 10–11	20	253
1943		
April 27–29	128	50
May 27–June 2	266	128
Sept. 17–18	230	3
1945		
April 21–23	356	119
Total	*16,817*	*13,821*

* The number of net-days per period was not uniform throughout the study because of variation in length of periods and in number of nets used.

that differences in catch ratios may have been due to differences in concentrations of the two kinds of fish at the various netting stations. It might be speculated further that the whites and blacks school by individual species and that the number of each species caught during any 1-week period was determined principally by chance, that is, by the number of schools encountering the nets. Another possible explanation for the unstable catch ratios is that, as a result of environmental changes, for example, changes due to weather, the two species behaved differently and reacted differently to hoop nets.

FOODS

The published observations of Forbes & Richardson (1920), Pearse (1919), Ricker & Lagler (1942), Eddy & Surber (1947), and Johnson (1945) show that the principal foods of both white crappies and black crappies are small fish, aquatic insects, and small crustaceans. The relative importance of the three types of food mentioned have differed considerably in the crappie collections studied by different men, possibly in consequence of local differences in food supplies or in the time of year collections were made.

Only limited observations were made on the feeding habits of white crappies in Lake Decatur. In the summer of 1936, the winter of 1936–37, and the spring of 1937 the stomachs of the white crappies from this lake were often found to be filled with small gizzard shad, *Dorosoma cepedianum*, which were abundant at that time.

Some findings of a previously unpublished study of the food of Rock River crappies made for the Natural History Survey by the late R. E. Richardson are shown in table 8.

Table 8.—Percentages of foods (by volume) found in the stomachs of 64 white crappies and 190 black crappies from the Rock River system, 1924–1927. Data from an unpublished study by R. E. Richardson.

Kind of Food	Percentage of Food by Volume	
	White Crappie	Black Crappie
Terrestrial insects	0.60	0.71
Aquatic insects	34 96	45 65
Other aquatic invertebrates	1 17	0.47
Fishes	57 88	44 07
Animal matter unclassified	5 06	8.72
Vegetable matter	0 12	0 04
Organic matter mixed	—	0 16
Earth and mineral matter	0 21	0 18
Total	*100 00*	*100.00*

MIGRATIONS

By means of tagging operations carried on in a number of the large rivers and adjoining lakes in various parts of Illinois, Thompson (1933) found that both white crappies and black crappies are given to travel. He observed upstream and downstream movements, and concluded that the movements of the crappies, as well as the other species tagged, are random or haphazard. Four white crappies were recaptured upstream, 3.5, 8, 16, and 18 miles from tagging points; three others were retaken downstream, 1, 2, and 3 miles from tagging points. The distances of travel were similar for the black crappies except that one black crappie was caught 77 miles upstream.

There is little if any indication from Thompson's study that these movements of crappies were related to spawning.

Eschmeyer (1942) found that six tagged crappies (kind not specified) in Norris Reservoir were retaken at distances of 0 to 18 miles from points of tagging.

Miller & Bryan (1947) reported recapture of nine tagged white crappies at distances of 0.1 to 1.2 miles from the point of tagging in Wheeler Reservoir, 6 to 41 days after the date of tagging.

REACTION TO CURRENT

At Lake Springfield, Sangamon County, in May, 1941, white crappies were observed concentrated in front of an 8-by-10-foot wire screen fastened to a culvert that delivered a large volume of water into the lake from an electric power plant. The water coming from the culvert entered the lake at the lake level, that is, there was no fall. The crappies could be caught

readily with a dip net. In 11 dips with a circular net measuring 2 feet across, 60 white crappies were taken. These measured 5 to 9 inches in length, averaging about 6 inches. Positive reaction to strong currents is, of course, well known for a number of species of fishes. No temperature readings were obtained at the culvert outlet.

REPRODUCTION

Biologists regard a knowledge of the facts of fish reproduction as of special importance in their efforts to bring about population increases in certain species of fish. Both kinds of crappies in Illinois waters show a strong tendency to reproduce in adequate numbers, so that artificial aids to reproduction have so far not seemed necessary. It is possible that a knowledge of the facts of crappie breeding may prove to be of use in the development of methods of limiting already overcrowded populations.

Sexual Maturity

Sexual maturity in Illinois white crappies is reached at the end of the second or third year, that is, at an age of about 24 or 36 months. There is no indication that white crappies in Illinois ever spawn when 1 year old, although spawning at 1 year has been observed in Texas black crappies (Harper 1938). Only about a third of the white crappies hatched at Lake Chautauqua in the spring of 1938 appeared to be approaching maturity as 2-year-olds (ages determined by scales and by size distribution) when specimens were examined in May, 1940. In a sample of 127 2-year-old females examined on May 16, dissections showed that the ovaries of only 40 contained well-developed (large) eggs. The ovaries of the other 87 females of that age group were still in an immature stage and it was believed that none of this group of 87 2-year-olds would reach maturity during the 1940 spawning season. The 40 mature females averaged 6.2 inches total length, while females in which the eggs were undeveloped averaged 5.8 inches.

Fully mature, 2-year-old white crappies (ages determined by scales) were captured at Lake Decatur on June 3–5, 1937; included were ripe individuals of both sexes. These fish averaged approximately 2 inches longer than the ones from Lake Chautauqua that did not seem to be maturing as 2-year-olds.

Among 2-year-old white crappies examined by Eschmeyer, Stroud, & Jones (1944) from one of the reservoirs of the Tennessee River, some were mature and others were not.

The smallest ripe white crappie observed in Illinois was a female of 5.6 inches, total length, caught on May 20, 1941, at Lake Springfield. The scales of this fish did not show clearly whether its age was 2 or 3 years.

Breeding Coloration

The coloring of male and female white crappies is identical except during and near the spawning season, when the breeding males typically turn darker, while the females typically remain unchanged in color. The darker coloring of the male, darker in some individuals than in others, is most noticeable on the sides of the head, chin, and breast, and to a lesser extent on the sides of the body. It begins to appear in April, reaches maximum intensity about the last of May, and is lost in most males by the last of June. The disappearance of the breeding color seems to take place gradually, and some males retain remnants of the breeding pigmentation well into July.

The following tests were made to discover the degree of error in using breeding color as a basis for sex recognition in spring collections of white crappies. The fish were first sorted as to sex on the basis of color; then they were opened and their reproductive organs were examined. In these tests, it was found that sex was usually guessed correctly, but that errors were sometimes made in fish large enough to be sexually mature as well as in small fish which may have been immature.

At Lake Decatur, 100 specimens were examined in the period May 17–20, 1939. Among 19 white crappies first judged to to be males by their dark pigmentation, dissection showed 18 males and 1 very darkly pigmented female. Among 81 judged to be females by the absence of dark pigmentation, dissection showed 2

males and 79 females. The true ratio was 20 males and 80 females, instead of 19 males and 81 females.

At Lake De Pue on April 26, 1942, 3 males and 12 females were correctly sexed by means of breeding color.

At Lake Springfield on May 20, 1941, a group of 36 white crappies classified as females on the basis of color included 7 light-colored males. Fish showing male pigmentation were not dissected.

Light-colored males in the tests were of the following total lengths: at Lake Springfield, 6.3, 6.3, 6.5, 6.6, 7.2, 7.2, and 8.4 inches; at Lake Decatur, 8.1 and 8.7 inches; and, at Lake Chautauqua, 8.7 and 9.8 inches. Some of the males, though possibly not all of them, were large enough to be sexually mature. The one female caught at Lake Decatur that was so dark it was mistaken for a breeding male was 10.2 inches long.

Spawning Season

After examining market specimens at Havana, Illinois, Forbes & Richardson (1920) gave May as the spawning time of the white crappie in this state. White crappies were observed on nests at Lake Springfield on May 26, 1941 (Hansen 1943). The black crappie evidently nests about the same time as the white. Forbes & Richardson reported that the black crappie spawned in May at Havana in 1898. Richardson (1913) found a nesting black crappie at Havana on May 2, 1911.

Frank Rhodes of Carlinville, Illinois, stated on the basis of several years of observation that crappies (kind not specified) nest at nearby Beaverdam Lake in May and again in September. September nesting has not been reported elsewhere and it is possible that the behavior of nesting was observed in September when nesting was not actually taking place.

Eddy & Surber (1943) reported that in Minnesota the white crappie spawns in late spring and early summer, and that the black crappie usually spawns in May and June but that spawning has been observed in July. Pearse (1919) found nesting black crappies at Madison, Wisconsin, on May 20, 1916.

Eschmeyer & Smith (1943) found that spawning of crappies might be delayed or prevented if the fish were kept at continuously low water temperatures.

The approximate spawning date of the white crappie in Illinois is further indicated by occurrence of ripe and unripe gonads, table 9. A ripe condition of the gonad was detected by squeezing, with moderate pressure, on the sides of the fish in the region just above the vent. Males were classified as ripe if they yielded milt, and females if they yielded runny, sticky, translucent eggs. An individual of either sex was not considered ripe if hard squeezing was required to obtain eggs or milt.

Squeezing tests indicate that May and June are perhaps equally important months for white crappie spawning in Illinois, and that the height of the spawning season usually falls in late May or early June. Field records noting the occasional finding of a ripe male or female show that some spawning may occur in July. Ripe male white crappies have been found as early as May 16 and as late as June 24, while ripe female white crappies have been found as early as May 6 and as late as July 13.

Changes in Ovary Size

Enlargement of the ovaries of white crappies has been observed in Illinois from early April through June or early July. This enlargement results from enlargement of the eggs. Squeezing tests indicate that some eggs ripen in advance of others and occasional dissections show that eventually the ovary contains practically a solid mass of ripe eggs. Close attention has not been paid to the time of year when the ovary starts to enlarge in preparation for a new spawning season. However, the occurrence of the reduced or post-spawning stage has been noted as follows at Lake Decatur: July 3–5, 1936, 16 females had reduced ovaries while 9 females still had more or less enlarged ovaries; July 31–August 3, 1936, all of the 39 females examined had reduced or immature ovaries, table 9. Presumably the July 31–August 3 collection included some mature females which had completed the spawning cycle.

Even though collecting was not continuous throughout the spawning period, the fact that the writer failed to observe a

Table 9.—Counts of sexually ripe[1] male and female white crappies in central Illinois.[2] All fish caught in 1-inch-mesh hoop nets, except as shown.

Date of Collection	Place	Males			Females		
		Number Examined	Number Ripe	Per Cent Ripe	Number Examined	Number Ripe	Per Cent Ripe
May 28, 1936[3]	Sangamon River, Decatur	5	1	20	4	1	25
May 29–June 4, 1936	Lake Decatur	39	1	3	63	21	33
July 3–5, 1936	Lake Decatur	17	0	0	28[4]	0	0
July 31–Aug. 3, 1936	Lake Decatur	43	0	0	39[5]	0	0
June 4, 1937	Lake Decatur	79	45	57	123	54	44
June 24, 1937[6]	Lake Decatur	—	—	—	81	—	5–10
May 28, 1938	Lake Decatur	—	—	—	15	1	7
May 17–20, 1939[3]	Lake Decatur	19	5	26	57	15	26
May 16–29, 1940	Lake Chautauqua	32	8	25	106	10	9
May 14–20, 1941	Lake Springfield	—	—	—	10	2	20

[1] Fish were designated as ripe if moderate pressure around vent resulted in extrusion of milt or sticky, translucent eggs.
[2] Lake Chautauqua, Mason County; Lake Decatur and Sangamon River, Macon County; Lake Springfield, Sangamon County.
[3] Examination of anglers' catch.
[4] Ovaries still noticeably enlarged in 9 females, ovaries much reduced in 16 females, classification intermediate or uncertain in 3 females.
[5] Ovaries much reduced or immature in all females.
[6] Some ripe males were found in this collection, but no complete count of ripe males was made. Of the total number of females taken, 81 were examined and the percentage of females ripe (5 to 10 per cent) was estimated immediately after the examination.

single empty ovary in a mature-size white crappie at the height of the spawning season in May and June is an indication that only part of the ripened contents of the ovary is voided in a single spawning act. Whether the white crappie female lays eggs in more than one nest was not learned.

The finding, in the latter half of the spawning season, of many white crappie females with enlarged but somewhat flabby ovaries, each containing large numbers of eggs, all opaque and unripe, suggests to the writer that an undetermined number of eggs, perhaps a considerable number, may be absorbed rather than laid.

Of another centrarchid, the bluegill, James (1946) reported, "Spawning appears to be intermittent during the summer months, but upon its completion resorption of the remaining eggs takes place. . . . . Evidence of resorption could be seen in sectioned materials from late August until December."

As a general rule, the enlargement of the crappie ovary at or near spawning time is not sufficient to produce a noticeable bulging of the sides of the fish. In the only instance the writer observed in which a large percentage of the female crappies had sides that bulged with eggs, the bulged condition was decidedly more prevalent in late April, in advance of the spawning season, than in late May, near the height of the spawning season. This observation was made on white crappies of about 11 inches and larger caught in hoop nets at Lake Chautauqua during the spring of 1940.

Nesting Habits

In common with all other centrarchids, crappies of both species guard their eggs and, like certain others, they do not invariably fan out nests. There is little uniformity in the sites they select.

Six white crappies, apparently nesting, were observed by the writer at Lake Springfield on May 26, 1941 (Hansen 1943). The six crappies, 6 to 7 inches in length, were in water 4 to 8 inches deep along an undercut sod bank of red clay. They were spaced 2 to 4 feet apart and were well concealed from the casual passer-by by the overhanging bank and by a

small elm tree that was growing in the water near the bank.

All six fish were moving the pectoral fins as if fanning eggs. They had not excavated nests, perhaps because the lake bottom at this place was hard and free of loose sediment. Close-range examination of the crappies and their surrounding territory failed to reveal eggs near four of the fish. Visible near one of the others were a few hundred eggs attached to dead blades of lawn grass and grass roots dangling in the water from the edge of the overhanging sod bank. The eggs were not more than 2 inches under the surface of the water; the fish guarding these eggs was actually below them. Guarded by another fish were at least a thousand eggs attached to a 3-inch ball of elm roots. The eggs averaged 0.89 mm. (0.034 inch) in diameter.

In 1940, L. J. Hoggatt, Springfield fisherman, found a single white crappie nest under the floor of a boathouse at Lake Springfield about 100 yards from the site of the writer's 1941 observations. In this case a thin layer of silt had been fanned away from a circular area 5 or 6 inches across, exposing a sandy bottom.

In line with the observation made above that probably only a small proportion of the eggs are deposited at one spawning act, the Lake Springfield fish observed in 1941 were guarding only a small fraction of the number of eggs which a female crappie is capable of producing. A similar situation was found among crappies which had spawned in a Washington, D. C., aquarium (Anonymous 1919). While egg counts have not been made on white crappie ovaries, Ulrey, Risk, & Scott (1938) made observations on numbers of eggs in black crappie ovaries which suggest the probable egg production of the white crappie. Their count showed from 27,000 to 68,000 eggs per black crappie female; the number of eggs depended on the age or size of the female examined. Eddy & Surber (1947) stated that a black crappie of 1½ pounds may have as many as 140,000 eggs in its ovaries.

There are similarities between nesting of the white crappies at Lake Springfield and published accounts of nesting of black crappies. The tendency of crappies to place their nests near some sort of vegetation is mentioned in various descriptions. In all cases where eggs of either species have been found they were attached to plant material. Considerable variation has been observed in depth of the water over the nests (from a few inches to 20 feet), in kinds of substrata (mud, clay, rock, sand, gravel, and concrete), and in distance of the nests from the shore.

At Havana, Illinois, Richardson (1913) found a black crappie nest hollowed out under the leaves of a water parsnip in water 10 inches deep. Other plants surrounding the nest included smartweed and bog rush. Most of the eggs were seen on the leaves of the water parsnip 2 to 4 inches above the bottom of the nest; others adhered to fine roots in the bottom of the nest.

Pearse (1919) found a number of black crappie nests at Lake Wingra, Madison, Wisconsin, along the edge of an undercut clay bank in water 2 feet deep; the nests were adjacent to an unidentified, submerged, aquatic plant.

At Lake Maxinkuckee, Indiana, Evermann & Clark (1920) found black crappies nesting on the sand and gravel bars at depths of 8 to 10 feet and shallower, the nests usually surrounded by chara. They gave the diameters of the nests as 8 to 9 inches.

Eddy & Surber (1947) wrote of the spawning of black crappies in Minnesota: "The nests are often close together and are sometimes built on bottoms that are softer and muddier than those usually chosen by members of this family."

An instance of crappie spawning at the Bureau of Fisheries Aquarium at Washington, D. C., is described in the magazine *Aquatic Life* (Anonymous 1919). The pair of fish involved had been at the aquarium for a number of years. Spawning occurred some time during the night of May 25. An estimated 6,000 eggs, some practically at the surface, were attached to algae, which formed a dense growth on the stones covering the steeply inclined back wall of the tank. The first young were seen on the morning of May 28 and all fertile eggs had hatched by May 31. As pointed out by Breder (1936), the *Aquatic Life* reference to the fish as a crappie rather than as a calico bass, or any other name for the black crappie, suggests

that the white crappie was probably the species under observation.

Nelson (1941) mentions that crappies (species not identified) spawned on cowlot manure straw in federal hatchery ponds at Elephant Butte, New Mexico. In letters to the writer, Mr. Nelson has given further details on crappie nesting both in these hatchery ponds and in nearby Elephant Butte Lake. In the ponds he observed that nesting was carried on in the open at water depths of 2½ to 5 feet; that the crappies nested in colonies; that the nests were scooped out, though not as deeply as those of other sunfishes; that the eggs were attached to straw (from the fertilizer), to "chara or other moss," but that the crappies sometimes spawned where there was nothing whatever for egg attachment; that the crappies did not use the gravel beds that were available in the ponds. Nelson observed quite different nesting sites at Elephant Butte Lake, where in clear water he had seen crappies nesting at depths of 10 to 20 feet, "on rocks, boulders, submerged brush and trees, but never on sand or gravel bars or beaches." Presumably he referred to white crappies, as Greenbank (1937) found no black crappies in Elephant Butte Lake during his net-fishing studies.

Over a period of 6 to 7 years, the writer interviewed a considerable number of persons in an effort to gather more information on spawning habits of crappies in Illinois. Only five persons among those questioned had observed the nesting of crappies. Mr. Hoggatt's observation on nesting at Lake Springfield has already been mentioned. None of the other four observers knew which species of crappie had been observed.

At Scott's Pond, near Mount Zion, Illinois, Paul S. Smith of that place observed a 12-inch crappie guarding a nest situated on the submerged top of a concrete retaining wall for an earth dam. The nest was somewhat concealed by surrounding vegetation.

An engineer at Staley's pumping station on Lake Decatur believed he had seen crappies in the act of spawning along the submerged sloping concrete facing at the foot of the Baltimore & Ohio Railroad embankment 15 feet from the pumping station. This concrete facing supported a growth of filamentous algae to which the engineer believed the eggs were attached. The situation in this instance was similar in important respects to that at the Washington Aquarium.

Frank Rhodes said that crappies at Beaverdam Lake spawned among aquatic plants along a shaded stretch of shore in water 1 to 2 feet deep. The fish had fanned away sediment to expose fine gravel or clumps of roots of nearby trees.

Anthony Kuderka of Taylor Springs, Illinois, saw crappie nests at Taylor Springs Lake on various occasions. He observed the nests in clear water near shore at a depth of about 2 feet. He described the nests as less deeply excavated than those of bluegills and always located near water plants.

As yet there have been no descriptions of nest building operations of crappies, nor has anyone described their mating behavior. Little is known about the behavior of the fish while guarding the nests. More information is needed on numbers of eggs deposited in nests and on losses of eggs because of predation or disease. The fact that nesting of crappies is not more often observed may be due to a preference for nesting sites within the concealment offered by water weeds, overhanging trees, undercut banks, and man-made structures. The turbid condition of most Illinois lakes in the spring is a hindrance to observation, and it is possible that the crappies usually nest in deeper water than that selected by the more frequently observed members of the sunfish family.

Sex Ratios

Sex ratios calculated for white crappies studied in Illinois varied with age and length of the fish, season of take, and method of capture.

Sex Ratios and Differential Survival of the Sexes.—In the Lake Decatur net samples, table 10, most of the young crappies were males and most of the older ones were females. Apparently, equality in sex ratio was present only from about the end of the second to about the end of the third year of life. It is not known to what extent the unbalanced sex ratio in these young crappies may have been the result of selectivity of the hoop nets.

Taken at face value the figures showing predominance of males among the two youngest broods could mean either that more males than females were hatched in these particular broods, or that the young females were subject to heavier early mortality than the young males.

Among older fish, on the other hand, the predominance of females over males was so great as to leave little doubt that after about the third year males die off much faster than females.

While it appears in table 10 that sex ratios shift as the fish become older, the possibility must be kept in mind that some broods may start out with a predominance of males and other broods with a predominance of females.

Table 10.—Ratios of males to females in Lake Decatur white crappies of different ages. All collections made with 1-inch-mesh hoop nets.

Age of Brood at Midpoint of Study, Months*	Brood	Period of Study		Number Examined of Both Sexes	Males	Females	Males per 100 Females
		July 31, 1936–July 16, 1937 ($11\frac{1}{2}$ Months)	Nov. 4, 1938–Jan. 9, 1939 (2 Months)				
18	1937		x	126	78	48	163
20	1935	x		557	321	236	136
31	1936		x	89	38	51	74
32	1934	x		783	350	433	81
44	1933	x		179	63	116	54
60	1932	x		12	0	12	0
73	1931	x		9	0	9	0
83	1930	x		3	1	2	50

* Brood age were computed from an assumed June 1 hatching date.

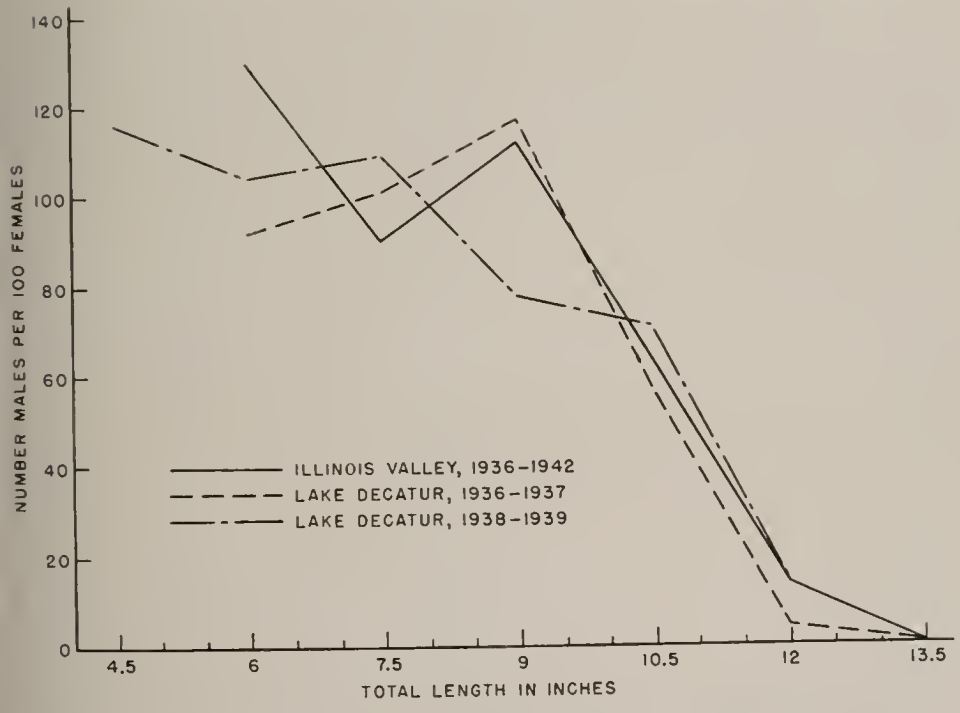

Fig. 5.—Changes in sex ratio of white crappies of different length classes. Data from Lake Decatur and from bottomland lakes of the Illinois River valley.

Corresponding somewhat with a change in sex ratios among crappies of different age classes is a change in sex ratios among crappies of different size classes. Collections from Lake Decatur and the Illinois River valley show a fairly well-defined

Table 11.—Ratios of males to females in white crappies of various lengths, as determined by observations on fish collected at Lake Decatur and in bottomland lakes of the Illinois River valley. All collections made with 1-inch-mesh hoop nets.

Total Length Class, Inches*	Lake Decatur						Illinois River Valley		
	July, 1936, to July, 1937			Nov., 1938, to Dec., 1939					
	Males	Females	Males per 100 Females	Males	Females	Males per 100 Females	Males	Females	Males per 100 Females
4½	0	1	—	103	89	116	1	0	—
6	25	27	92	366	351	104	43	33	130
7½	132	131	101	470	430	109	75	83	90
9	446	380	117	219	280	78	139	124	112
10½	190	331	57	59	83	71	64	102	63
12	1	25	4	6	45	13	6	46	13
13½	0	6	0	0	14	0	0	4	0
15	—	—	—	—	—	—	0	1	—

* Class center is indicated; the 4½-inch class includes fish of 3.8 through 5.2 inches total length; the 6-inch class includes fish of 5.3 through 6.7 inches.

Table 12.—Ratios of males to females in white crappies taken in different months, as observed in entire hoop-net catches at Lake Decatur.

Date of Collection	Number of Specimens	Males	Females	Males per 100 Females
1936				
May 29–June 4	100	37	63	59
July 3–5	45	17	28	61
July 31–Aug. 3	82	43	39	110
Sept. 8–22	88	52	36	144
Oct. 24–27	228	119	109	109
Dec. 21	295	153	142	108
1937				
March 1–4	297	150	147	102
April 24	115	41	74	55
June 3–5	225	91	134	68
June 24	133	52	81	64
July 10–16	84	38	46	83
1938				
Nov. 4–11	73	37	36	103
1939				
Jan. 9	153	87	66	132
March 24	315	156	159	98
May 3	146	75	71	106
May 29	118	39	79	49
June 20	135	70	65	108
July 13–17	313	165	148	111
Aug. 24	80	44	36	122
Oct. 16	266	134	132	102
Dec. 11	817	402	415	97
Total	*4,108*	*2,002*	*2,106*	*95*

shift in sex ratios from a preponderance of males among small crappies to a preponderance of females among large ones, table 11 and fig. 5.

In the longear sunfish, *Lepomis megalotis peltastes,* studied by Hubbs & Cooper (1935), the age-sex ratio trend was similar to that of the white crappie of Lake Decatur, although the preponderance of females among the older longear sunfish was restricted to fish in the fifth summer. In the green sunfish, *L. cyanellus,* studied by Hubbs & Cooper (1935), in the bluegill, *L. macrochirus,* studied by Schoffman (1938), and in the redear sunfish (western shellcracker), *L. microlophus,* studied by Schoffman (1939), collections of older fish tended to be predominantly male.

Seasonal Variations in Sex Ratios of Fish Taken in Hoop Nets.—In the white crappies of Lake Decatur, the date of sampling appeared to have a bearing on the calculated sex ratio, table 12 and fig. 6. In most fall, winter, and early spring collections, males were more numerous than females, while in most late spring and early summer collections males were less numerous than females. A drop in the relative numbers of males approximately paralleling that seen at Lake Decatur in the spring of 1939 was observed in the hoop-net samples at Lake Chautauqua in the spring of 1940, as follows: a sample of 152 white crappies caught April 24 and 25 showed a ratio of 127 males per 100 females, while a sample of 503 specimens taken May 22–28 showed a ratio of only 26 males per 100 females. This spring-summer scarcity of males might be expected to have been the result of the more prolonged involvement of the males with nest construction and guarding. However, reference to fig. 6 shows that in certain years the period of male scarcity at Lake Decatur was somewhat longer than the major spawning season.

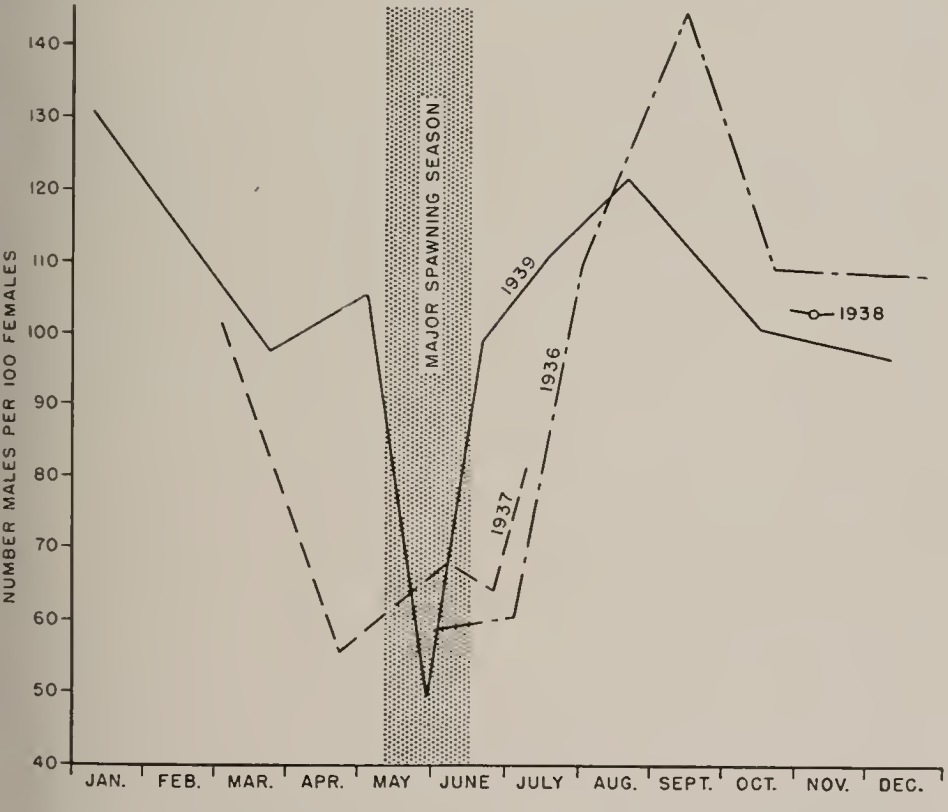

Fig. 6.—Seasonal variation in sex ratio for entire samples of white crappies collected during different years at Lake Decatur. Only one observation on sex ratio was made in 1938.

Because of the comparatively short life-span of broods, table 20, a new brood in the net catches generally made up an important percentage of the total sample. It is worth while to consider that, if the members of a new brood entering the net samples were predominantly one sex or the other, it would have an important effect on the sex composition of the catch as a whole. In the Lake Decatur sampling, second-year fish that first entered the net catches in 1936 and 1938 at ages of 13–17 months were predominantly male, table 10, a fact that may partially explain the predominance of males in some of the entire net catches recorded in table 12. When a preponderance of females appears in collections made before another new brood is taken in the nets, it may be explained by a generally higher mortality rate among males that, data indicate, occurs some time after the middle of the second year.

Variations in Calculated Sex Ratios Resulting From Inadequate Sampling.—Inadequate sampling of fish populations may result in calculated sex ratios that fail to reflect the actual ratios in the populations sampled.

The following is an example of sex ratio variation which may arise even when the samples are large. At Lake Chautauqua in 1940, a striking difference in sex ratios was observed in samples taken on consecutive days: from a ratio of 14 males per 100 females on May 22 to a ratio of 51 males per 100 females on May 23. The locations of the nets were slightly different on the 2 days. The ratios were calculated from 308 fish the first day and 186 the second.

Sex Ratios in Two Hook-and-Line Catches.—Two observations on the sex of white crappies taken by hook and line were made at Lake Decatur. In each observation, males were much less numerous than females. On May 16, 1937, when scales and measurements were taken from 86 fish, it was estimated on the basis of breeding color that not more than 10 per cent of the 86 fish were males. On May 17–20, 1939, when 100 fish taken by anglers were sexed by gonad examination, the ratio was found to be 20 males to 80 females. In terms of number of males per 100 females, the sex ratios in these two catches were 11 and 25, respectively. A comparison of these ratios with those in table 12 will show that males were relatively scarcer in the anglers' catches than in any of the hoop-net catches at Lake Decatur.

DISEASE

The virus disease, lymphocystis, which appears in the form of white, granular, irregularly shaped lumps on the fins and bodies of fish, is the only disease known to occur commonly in Illinois crappies. It is found in both the white crappie and black crappie. An individual lump may cover as much as half a square inch of surface. In diseased fins the ends of the rays are sometimes missing, but the disease is not known to be fatal.

In counts made on fish from bottomland lakes in the Illinois River valley, lymphocystis was found in 1.4 per cent of the white crappies caught at Senachwine Lake, April 29, 1942, in 9.5 per cent of those caught at Lake De Pue, April 25–27, 1942, and in 19.5 per cent of those taken at Lake Chautauqua, September 17–18, 1943.

Some of the more recent investigations on lymphocystis are those of Nigrelli & Smith (1939) and Weissenberg (1939). Weissenberg has shown that the granular appearance of the lumps is due to enlargement of connective tissue cells.

ABNORMALITIES

The principal abnormalities observed in the white crappie relate to color and structure. Excessive slime production was observed in one locality.

Color and Structure

Usually the white crappie is easily distinguished from the black crappie on the basis of coloration. In the white crappie, the dark markings on the sides tend to form faint vertical bars or rings, while in the black crappie the dark markings produce an over-all mottling. It has been the experience of the writer to find rather frequent departures from these characteristic patterns in crappies smaller than 4 inches and larger than 10 or 11 inches. In many of these individuals, the dark markings are

not arranged in a manner that allows for positive species separation on the basis of color pattern alone.

Structural freaks among crappies have been observed by the writer a number of times. Many of these have the low angle of the mouth of the white crappie but the deep body and pigmentation of the black crappie. No observation was made on these specimens of the number of dorsal spines—usually different in white crappies and black crappies.

Humpbacks and foreshortened bodies, both resulting from disease of the spine, are conditions that have occasionally been seen in the white crappie as well as in other species of Illinois fish.

Excessive Sliminess

A heavy coating of mucus was observed by the writer in a large percentage of both white crappies and black crappies taken during fishing operations at Lake Chautauqua on April 10, 1941. The mucus tended to foam when the fish were emptied from the nets into the boat and made the fish unusually slippery in handling. This was the only occasion when excessive mucus was observed on crappies, but the condition was observed in the gizzard shad caught at Lake Chautauqua on September 17 and 18, 1943. The cause of this abnormal secretion of mucus was not determined.

Table 13.—Standard lengths and equivalent total lengths of white crappies. From a graph based on the measurements of 96 white crappies taken at Horseshoe Lake, Alexander County, Illinois, February 22–28, 1938. See section "Methods and Techniques" for definitions of standard length and total length.

STANDARD LENGTH, INCHES	TOTAL LENGTH, INCHES
2.0	3.0
2.5	3.5
3.0	4.1
3.5	4.7
4.0	5.3
4.5	5.9
5.0	6.5
5.5	7.1
6.0	7.7
6.5	8.3
7.0	8.9
7.5	9.5
8.0	10.1
8.5	10.7
9.0	11.3
9.5	11.9
10.0	12.5

CONDITION OR PLUMPNESS

The coefficient of condition, K, representing relative plumpness was computed for white crappies from Lake Decatur and three other Illinois lakes by means of the formula:

$$K = \frac{\text{Weight in grams}}{\text{Standard length in centimeters}^3} \times 100$$

Length classes in this part of the paper are presented in terms of standard length rather than total length. Equivalent measurements in inches for standard and total lengths of white crappies are given in table 13. Original length and weight measurements in inches and pounds were converted to centimeters and grams as necessary for the computation of K values.

Seasonal Changes in K Values

This discussion, emphasizing seasonal variation in K values, is based on the collections made at Lake Decatur between April 3, 1936, and January 9, 1939. The build of the Lake Decatur crappies at the time of these observations appeared to be fairly typical of the build of crappies usually seen in Illinois; the seasonal changes in plumpness were not noticeable in the build of the fish. The average K values for members of various length classes appear for each collection date in table 14. The seasonal trends in average K values for the most abundantly represented length classes can best be followed in fig. 7. Some of the unevenness in the curves is quite obviously due to an insufficiency of specimens in some length classes.

That an average K value based on a small sample might not be truly representative of a length class is apparent from the wide spread of K values found among different individuals of a length class on the same date, table 15. The K values for two dates are shown in this table.

In describing seasonal changes in plumpness, it is necessary to make separate mention of the changes in large and small

Table 14.—Seasonal fluctuations in the coefficient of condition (K) in Lake Decatur white crappies of different standard length classes. Some of these data are plotted in fig. 7. Figures in parentheses represent numbers of specimens.

Date of Collection	Standard Length, Inches[1]								
	3	4	5	6	7	8	9	10	11
1936									
April 3	2.34 (3)	2.23 (101)	2.37 (85)	2.77 (77)	2.93 (42)	3.10 (16)	3.11 (1)	—	—
May 4–10	—	2.45 (25)	2.42 (15)	2.78 (26)	2.99 (12)	2.93 (2)	3.16 (4)	3.23 (2)	2.57 (1)
May 29–June 4	—	2.66 (5)	2.63 (17)	2.67 (37)	2.77 (25)	2.80 (12)	2.81 (2)	3.03 (3)	—
July 3–5	—	3.20 (2)	3.00 (11)	3.01 (26)	2.88 (3)	2.76 (2)	—	—	—
July 31–Aug. 3	—	2.65 (4)	2.87 (45)	3.03 (13)	3.04 (18)	2.57 (1)	—	—	—
Sept. 8–14	2.66 (2)	2.94 (1)	2.88 (3)	3.02 (11)	3.17 (8)	3.33 (4)	—	—	—
Sept. 22	—	—	2.62 (5)	2.98 (36)	3.06 (14)	3.04 (6)	—	—	—
Oct. 24–27	—	2.12 (1)	2.17 (2)	2.78 (21)	3.02 (95)	3.24 (107)	3.43 (11)	—	—
Dec. 21	—	—	2.79 (1)	2.96 (37)	3.17 (165)	3.29 (88)	3.48 (4)	—	—
1937									
March 1–4	—	—	2.08 (1)	2.84 (48)	3.03 (116)	3.26 (162)	3.37 (17)	3.00 (1)	3.26 (1)
April 24	—	—	2.31 (3)	2.57 (12)	2.90 (36)	3.09 (63)	3.31 (3)	—	—
May 16[2]	—	—	—	2.64 (4)	2.96 (44)	3.08 (33)	3.14 (5)	—	—
June 3–5	—	—	2.40 (3)	2.62 (26)	2.69 (75)	2.77 (103)	2.93 (16)	2.95 (2)	—
June 24	—	2.74 (4)	2.58 (1)	2.67 (9)	2.70 (37)	2.76 (71)	2.74 (12)	2.83 (4)	2.94 (2)
July 10–16	—	2.66 (6)	2.28 (2)	2 62 (11)	2.68 (34)	2.62 (35)	2.56 (2)	2.69 (4)	—
Aug. 6–14	—	2.67 (12)	2.71 (33)	2.76 (6)	2.86 (11)	2.91 (7)	3.06 (2)	—	—
Sept. 22	—	2.58 (12)	2.55 (149)	2.63 (47)	2.84 (5)	3.08 (3)	3.17 (1)	—	—
Nov. 3	—	2.41 (22)	2.43 (123)	2.61 (19)	2.97 (4)	3.17 (2)	—	—	—
1938									
Jan. 17–24	—	—	2.42 (11)	2.64 (1)	2.77 (1)	—	3.31 (2)	3.43 (2)	—
March 14	—	2.33 (24)	2.32 (112)	2.63 (41)	2.93 (12)	3.19 (13)	3.37 (8)	3.40 (1)	3.38 (1)
May 28	—	2.21 (35)	2.21 (40)	2.42 (8)	2.73 (3)	2.98 (4)	3.02 (8)	3.14 (2)	—
July 14	2.81 (1)	2.56 (21)	2.52 (6)	—	—	—	3.46 (1)	—	—
Aug. 25	2.79 (2)	2.48 (25)	2.66 (33)	2.78 (12)	2.78 (3)	3.29 (1)	2.96 (1)	—	—
Oct. 6	—	2.29 (1)	2.50 (18)	2.75 (39)	3.02 (8)	3.25 (3)	—	—	—
Nov. 4–11	—	2.41 (1)	2.35 (14)	2.73 (26)	2.93 (17)	3.08 (13)	3.18 (2)	3.11 (1)	—
1939									
Jan. 9	2.23 (1)	2.22 (5)	2.33 (14)	2.75 (45)	3.04 (64)	3.18 (21)	3.31 (3)	3.06 (1)	—

[1] Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.
[2] Sample obtained from anglers.

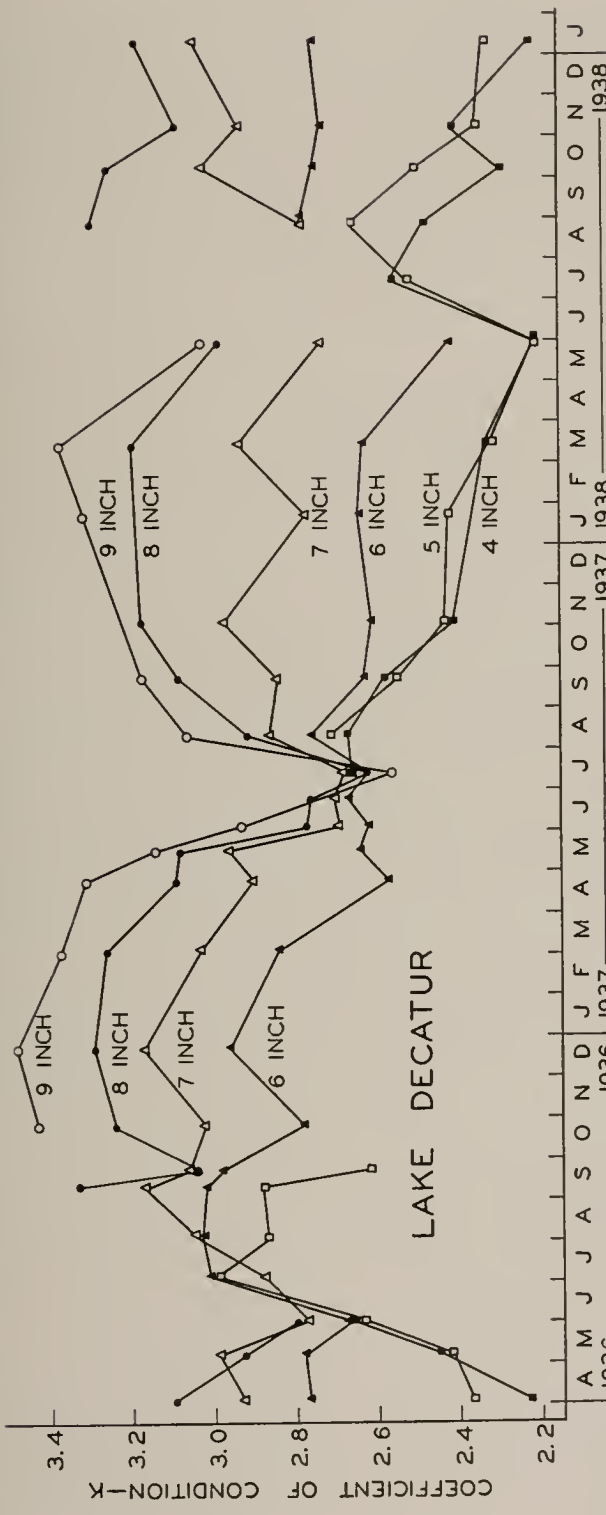

Fig. 7.—Seasonal fluctuations in the coefficient of condition (K) for white crappies of different length classes at Lake Decatur. (Data from table 14.)

crappies. White crappies over 7 inches (standard length) may be regarded as mature and those under 5 inches as immature. The seasonal changes may be summarized as follows:

Large sizes, crappies 7 inches standard length and smaller: Condition values increased rapidly through middle and late summer, reached a yearly peak in late fall or early winter, remained at a high level through the cold months, dropped sharply during the spring, and reached the lowest point in early summer.

Small sizes, crappies 5 inches standard length and smaller: Condition values increased from the middle of spring through early summer, reached a yearly peak in midsummer, fell off through late summer and fall, remained stationary through the cold months, and fell again through early spring.

Condition changes of crappies in the 6-inch class were approximately intermediate between changes described for fish of the two size classes discussed above.

Differences between large and small fish with respect to condition changes may be summarized as follows: The small crappies began to fatten earlier in the growing season than the large crappies, reached peak condition in midsummer rather than late fall or early winter, and lost condition in spring and again in late summer and fall, rather than only in the spring and early summer.

In fish that were less than 5 inches long at the start of the growing season and that grew to a length greater than 7 inches, the fall and subsequent spring changes in condition followed those described for the larger fish.

Increases in K values occurred only during the annual growing period.

Upward and downward trends in large and small fish described above for various seasons of the year have, for the most part, been based on observations made during 2 calendar years. The evidence of winter-to-spring drop in condition in large fish rests mainly on observations in 1937 when large sizes were abundant; winter observations were lacking for 1935–36, and large fish were scarce in the first half of 1938.

Fish of given sizes did not always show the same K values in corresponding months of different years. The 8-inch and 9-inch classes showed more uniformity in this respect than the smaller fish.

A tendency for large fish to have higher K values than small ones was observed in the smallmouth bass by Bennett (1938), in the largemouth bass by Thompson & Bennett (1939), and in the bluegill by Bennett, Thompson, & Parr (1940). Such a relationship was also found in the Lake Decatur white crappies but was unapparent or inconspicuous at certain times of the year—especially in June and July. The similarity of K values in all sizes of white crappies at that time of year may be ascribed to two things: (1) Late winter and early spring weight losses were relatively greater in large fish than in small ones (compare the changes in K values in the 6-inch to 9-inch classes from March to June, 1937) and (2) summer gains in K values started earlier in small fish than in large ones. Adequate data on the spread of K values are not available for June and July, 1938, because no collecting was attempted in June, and the July collection included only a few large fish.

A limited number of comparisons between K values of males and females of various lengths, table 16, indicates that the seasonal changes in condition occur in both sexes and that throughout the year K values tend to be a little higher in males than in females. Stroud (1948) found no important difference in plumpness between the sexes of black crappies in Norris Reservoir, Tennessee.

In black crappie collections made at several different times of year, Stroud (1948) did not find important differences in plumpness among four age categories or among size groups ranging from 4 to 12 inches. The failure of his data to show important differences is perhaps explained by the fact that most of his collecting was done in the spring, which, as indicated by observations at Lake Decatur, is a time of year when large and small crappies are of similar plumpness.

Changes in the average K value for members of various broods taken in the nets between early April, 1936, and early January, 1939, may be seen in table 17 and fig. 8. Broods represented in the nets by only a few specimens have been omitted from the table and graph. The longest

period of observation of any brood was about 2 years. A certain amount of resemblance may be seen between the curves in figs. 7 and 8. In general, the seasonal

Table 15.—Examples of the distribution of coefficient of condition (K) in white crappies of four size categories, 6–9 inches standard length, at Lake Decatur, March 1–4, and June 24, 1937. These dates were arbitrarily selected.

K Value	Standard Length* of Fish Collected, March 1–4, 1937				Standard Length* of Fish Collected, June 24, 1937			
	6 Inches	7 Inches	8 Inches	9 Inches	6 Inches	7 Inches	8 Inches	9 Inches
2.0	—	—	—	—	—	—	—	1
2.1	—	—	—	—	—	—	—	—
2.2	—	—	—	—	—	1	—	—
2.3	—	—	—	—	—	—	1	—
2.4	1	—	—	1	—	2	3	—
2.5	—	—	—	—	2	4	8	—
2.6	11	2	—	—	2	8	6	2
2.7	9	5	—	—	3	8	14	3
2.8	5	11	2	—	2	7	16	4
2.9	11	27	6	—	—	6	16	1
3.0	4	16	11	1	—	1	7	3
3.1	4	23	23	—	—	—	—	—
3.2	2	11	39	—	—	—	1	—
3.3	—	16	24	3	—	—	1	—
3.4	—	2	30	6	—	—	—	—
3.5	1	1	16	3	—	—	—	—
3.6	—	1	7	2	—	—	—	—
3.7	—	1	3	1	—	—	—	—
Total	*48*	*116*	*161*	*17*	*9*	*37*	*71*	*12*
Average K	2.84	3.03	3.26	3.37	2.67	2.70	2.76	2.74

* Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

Table 16.—Coefficient of condition (K) in Lake Decatur white crappie males and females of different length categories. Values of K were not computed where the sexes were not represented by at least 16 specimens. Figures in parentheses represent numbers of specimens.

Date of Collection	Standard Length* and Sex							
	5 Inches		6 Inches		7 Inches		8 Inches	
	Male	Female	Male	Female	Male	Female	Male	Female
1936								
May 29–June 4	—	—	2.69 (16)	2.64 (19)	—	—	—	—
July 31–Aug. 3	2.95 (26)	2.88 (19)	—	—	—	—	—	—
Oct. 24–27	—	—	—	—	3.09 (51)	2.94(37)	3.29 (53)	3.19 (52)
Dec. 21	—	—	2.90 (18)	3.00 (20)	3.20 (94)	3.12 (72)	3.31 (38)	3.25 (50)
1937								
March 1–4	—	—	—	—	3.04 (66)	3.01 (36)	3.27 (69)	3.25 (86)
April 24	—	—	—	—	3.01 (16)	2.82 (20)	3.16 (18)	3.05 (45)
June 24	—	—	—	—	2.78 (20)	2.60 (17)	2.85 (26)	2.71 (45)
July 10–16	—	—	—	—	2.77 (16)	2.57 (16)	—	—
1939								
Jan. 9	—	—	2.74 (23)	2.75 (22)	3.00 (37)	2.97 (28)	—	—

* Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

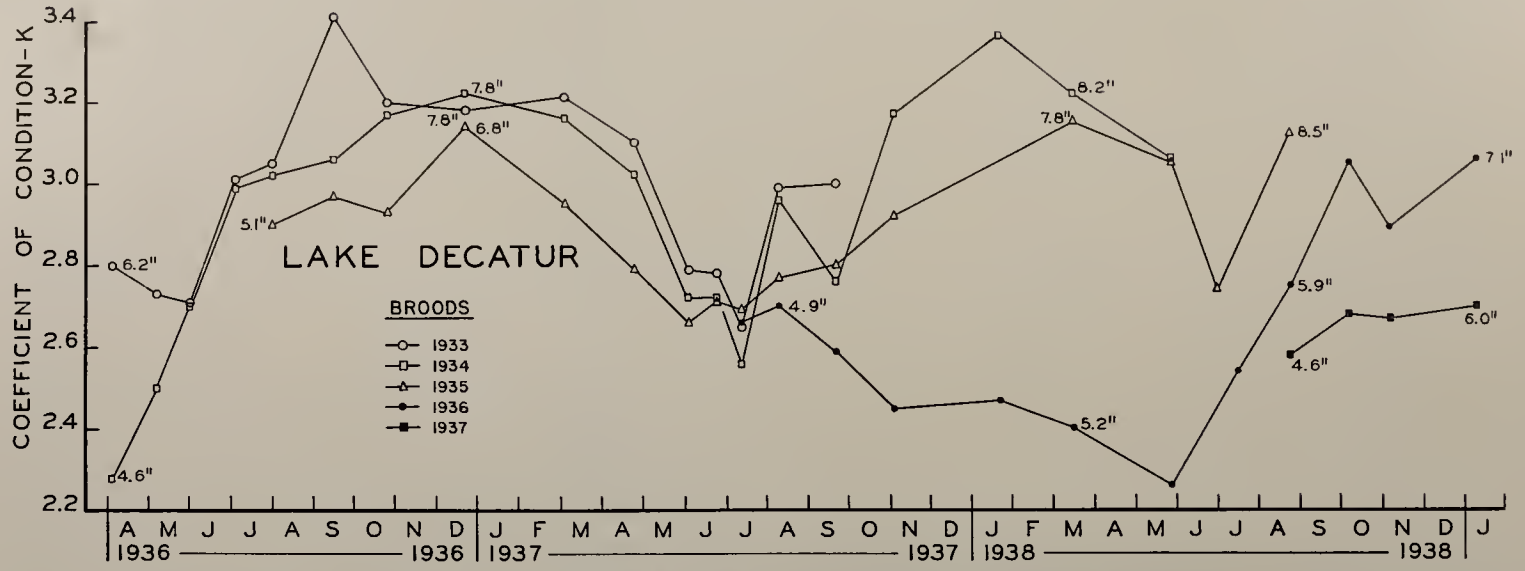

Fig. 8.—Seasonal fluctuations in the coefficient of condition (K) for white crappies belonging to various broods hatched at Lake Decatur, 1933–1937. The major changes in average lengths of individuals of the broods during the period of observations may be seen in the length figures which appear at intervals along the curves. (Data from table 17.)

fluctuations in condition summarized for small fish were similar to those occurring in young fish, and the fluctuations summarized for large fish were similar to those occurring in old fish. Differences in condition between adjoining broods were, as a rule, small, unless members of the adjoining broods differed considerably in length.

Late-summer trends in condition were especially variable from year to year in second-year fish, fig. 8. A late-summer rise in condition was observed in broods making good or moderately good late-summer growth (1935 brood in 1936, and 1937 brood in 1938), but a late-summer loss of condition was observed in a brood whose late-summer growth was small (1936 brood in 1937). The amount of late-summer growth can be seen from the average lengths of fish printed along the curves in fig. 8. With reference to the condition changes in the 1935 brood in late summer of 1936 and the 1937 brood in late summer of 1938, it is apparent that while each brood, taken as a whole, showed a rise in condition, fig. 8, the smaller (4-inch and 5-inch fish, fig. 7) were losing condition.

Eschmeyer, Stroud, & Jones (1944) observed condition changes in white crappies which they refer to as 2-year-olds (apparently the 1940 brood) at Chickamauga Reservoir, Tennessee, from March to October, 1942. This brood of white crappies reached peak condition in June and showed little change in condition from June to October, thus following the trends observed in Lake Decatur crappies of similar age and making the same sort of poor late-summer growth.

Measurements of condition of white crappies in three other Illinois lakes may be seen in table 18. Generally, fish from

Table 17.—Seasonal fluctuations in average coefficient of condition (K) in several broods of Lake Decatur white crappies. Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	1933 BROOD	1934 BROOD	1935 BROOD	1936 BROOD	1937 BROOD
1936					
April 3	2.80 (152)	2.28 (168)	—	—	—
May 4–6	2.73 (18)	2.50 (44)	—	—	—
May 29–June 4	2.71 (59)	2.70 (24)	—	—	—
July 3–5	3.01 (5)	2.99 (36)	—	—	—
July 31 Aug. 3	3.05 (4)	3.02 (27)	2.90 (51)	—	—
Sept. 8–14	3.47 (2)	3.15 (11)	2.99 (14)	—	—
Sept. 22	3.28 (1)	2.97 (11)	2.97 (49)	—	—
Oct. 24–27	3.20 (17)	3.17 (139)	2.93 (69)	—	—
Dec. 21	3.18 (18)	3.22 (107)	3.14 (171)	—	—
1937					
March 1–4	3.21 (53)	3.16 (220)	2.95 (67)	—	—
April 24	3.10 (14)	3.02 (67)	2.79 (35)	—	—
May 16*	3.02 (10)	3.07 (39)	2.93 (37)	—	—
June 3–5	2.79 (32)	2.72 (116)	2.66 (62)	—	—
June 24	2.78 (27)	2.72 (73)	2.71 (27)	—	—
July 10–16	2.65 (15)	2.56 (37)	2.69 (29)	2.66 (6)	—
Aug. 6–14	2.99 (2)	2.96 (8)	2.77 (13)	2.70 (45)	—
Sept. 22	3.00 (2)	2.76 (2)	2.80 (7)	2.59 (206)	—
Nov. 3	—	3.17 (2)	2.92 (3)	2.45 (165)	—
1938					
Jan. 17–24	—	3.36 (3)	—	2.47 (12)	—
March 14	—	3.22 (14)	3.15 (16)	2.40 (181)	—
May 28	—	3.06 (8)	3.05 (4)	2.26 (84)	—
July 1	—	—	2.74 (4)	—	—
July 14	—	—	—	2.54 (24)	—
Aug. 25	—	—	3.12 (2)	2.75 (19)	2.58 (56)
Oct. 6	—	—	—	3.05 (9)	2.68 (59)
Nov. 4–11	—	—	—	2.89 (17)	2.67 (49)
1939					
Jan. 9	—	—	—	3.06 (71)	2.70 (77)

* Sample obtained from anglers.

Table 18.—Average coefficient of condition (K) for various standard length groups of white crappies at Horseshoe Lake, Craborchard Lake, and Senachwine Lake. Figures in parentheses represent numbers of specimens.

Lake	Date	Standard Length, Inches*								
		4	5	6	7	8	9	10	11	12
Horseshoe (Alexander County).....	Feb. 19–28, 1938..	—	2.75 (31)	2.48 (26)	2.42 (7)	2.76 (4)	3.12 (5)	3.03 (6)	3 32 (10)	3.17 (5)
Craborchard (Williamson County).....	March 23, 1944...	—	—	—	—	3.70 (3)	3.66 (4)	4.18 (4)	4.03 (2)	—
Senachwine (Putnam County).....	Aug. 18–31, 1933..	2 85 (16)	2 84 (38)	2.91 (8)	2.99 (3)	—	—	—	—	—
	Sept. 1–16, 1933	2 85 (11)	2.84 (19)	2.93 (11)	2 95 (5)	—	—	—	—	—
	Sept. 21–29, 1933..	2.65 (8)	2.82 (44)	2.82 (13)	3 08 (9)	—	—	—	—	—
	Oct. 1–13, 1933...	2.82 (4)	2 66 (35)	2.85 (24)	3.10 (14)	3 12 (4)	—	—	—	—

* Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

these lakes show an increase in K with increase in length. An exception may be cited in the Horseshoe Lake data, where the K value of the 5-inch class was considerably higher than the K values for the 6-inch and 7-inch classes.

The condition values of 13 white crappies taken at Craborchard Lake in March, 1944, were much higher than the values observed in crappies of the same size elsewhere in Illinois. In these Craborchard specimens, high condition had accompanied rapid growth. Craborchard Lake was new in 1939. These large Craborchard specimens were observed to be deep bodied in proportion to their lengths and unusually plump in their abdominal regions. The body cavities of dissected specimens contained exceptionally large deposits of fat. No such large deposits were seen in the white crappies of Lake Decatur. In the same Craborchard collections, fish of small sizes appeared to be much less plump than those of large sizes, but they were not weighed and their K values were not determined.

While working for the Natural History Survey at Senachwine Lake on July 31, 1933, Lyle E. Bamber measured and weighed 16 white crappies which ranged from 35 to 49 mm. (1.4 to 2.0 inches) standard length. From their lengths and the absence of annuli on their scales, they were judged to be about 2 months old. They were the only young-of-the-year crappies studied. Their K values varied from 2.01 to 2.46 (average 2.20). Length and weight measurements were made with the degree of accuracy desirable for such small fish, as described in the section "Methods and Techniques."

Collections of 4- to 7-inch white crappies measured at Senachwine Lake during the period August 18 to October 13, 1933, showed changes in condition that approximately corresponded with the autumn changes in condition in 4- to 7-inch crappies at Lake Decatur; the 4-, 5-, and 6-inch classes showed a loss in condition and the 7-inch class a slight rise in condition from August to October, table 18.

Possible Reasons for K Loss

The fact that spring was a time of sharp decline in plumpness of Lake Decatur white crappies suggests a possible connection between weight loss and spawning. The major weight loss in mature white crappies occurred over a 2-month period preceding the nesting season. It appears likely that, in the years we are dealing with, most of the nesting took place within the period May 15 to June 15. Russell (1914) suggested that a prespawning condition loss in the haddock was caused by diversion of food materials to the ripening sex organs. But since two other species, the sardine studied by Clark (1928) and the bluegill studied by Bennett, Thompson, & Parr (1940), showed a rise in condition just before spawning and also since there was a spring loss of condition in immature crappies, it is appropriate to look for other explanations than the one offered by Russell.

Clark (1928), Mottley (1938), and Bennett, Thompson, & Parr (1940) all observed a loss in condition after spawning.

The condition losses in mature white crappies are too large to be accounted for by reduction in weight of the ovaries and testes after spawning. Weighing of the gonads of a few white crappies ranging from 6.5 to 10 inches standard length showed that just before the spawning season the ovary weight amounted to 6 per cent of the total body weight, and the testes weight amounted to less than 1 per cent of the total body weight, while the average winter-to-spring weight loss of the entire fish amounted to about 15 per cent in both sexes.

It was found, as already mentioned, that small white crappies underwent a loss in condition in late summer and fall when they were increasing slowly in length. The possibility can be disregarded that the spring condition loss of larger fish was brought about by growth in length of the crappies without sufficient gain in weight to maintain K values at a constant level. Annulus formation studies showed that only a few of the mature Lake Decatur white crappies had started their 1937 growth by early June, and that the majority delayed their 1937 growth until July or August. Thus, at the time of their spring loss in condition, the large crappies were not growing in length.

Other possible reasons for spring condition loss among white crappies include

disease, seasonal scarcity of fattening foods (or food in general), and difficult feeding conditions resulting from high turbidity. Disease as a possible reason for weight loss is suggested by the apparent high summer mortality of Lake Decatur crappies, a mortality indicated by low net catches in summer, table 20. No data are available on seasonal variations in crappie foods at Lake Decatur. It is not known that high turbidity in spring seriously interfered with crappie feeding. On the contrary, crappies caught in the spring of 1937 seemed to be having considerable success in capturing gizzard shad.

The reason for late-summer loss of condition in small crappies remains as obscure as the reason for their condition loss in the spring.

AGE AND GROWTH

The uses to which growth data on fish may be put depends in large measure on the accuracy of age determinations. In many instances, annual rings on the scales of white crappies appear to give only approximations of age, and the practical application of the scale method of age determination in these fish has been limited in Illinois mainly to detection of stunted populations.

Age Determination

Evidence was obtained at Lake Decatur during studies on date of annulus formation in white crappies that the age rings, fig. 9, are not invariably formed at the rate of one ring for each year of life nor at exactly the same time of year. This evidence may be summarized as follows:

1. In 1935 and 1937 some individuals failed to form annual rings because they did not grow in those years. While the observed cases of failure to form these rings appeared to include only a small proportion of the total population, there seemed to be a possibility that the percentage of cases was high in certain broods.

2. In the collection of September, 1937, 65 per cent of the members of the 1936 brood had two annuli, one of which was necessarily false. The false annulus, or the one thought to be false, while comparatively inconspicuous in some individuals, was well defined in others; some annuli showed cutting-over similar to that shown in fig. 9 and in other respects bore a close resemblance to the rings ordinarily considered to be true year marks.

3. In many scales collected at Lake Decatur the first annulus was indistinct and in some scales it was missing. Commonly the first annulus was present on some scales but absent on other scales of the same fish. A similar variation in visibility of supposedly first rings was commonly observed in collections from other Illinois localities.

4. Annulus formation occurred in different individuals at quite different times in the spring or summer from early May to late August, table 23. The over-all period in which different fish in the population were forming annuli lasted from 6 weeks in some years to 10 weeks or longer in other years.

White crappies collected during the period of annulus formation cannot be aged accurately by scale reading unless, under rather unusual circumstances as at Lake Decatur, the fish can be assigned to broods on the basis of scale patterns, fig. 10. No method has yet been discovered for determining in all cases whether marginal growth represents growth of the current season or of the previous season. While absorption at the edge of the white crappie scale (in summer collections) apparently indicates that the new year's growth has been delayed (Hansen 1937), the lack of absorption may not mean that growth of the current year has already started. Absorption seems to be of irregular and unpredictable occurrence. Summer, then, is not the most favorable time for collecting scales for age studies.

From the Lake Decatur collections it appears, in spite of many exceptions, that formation of one ring for each year of life is at least usual in white crappies. But the fact that many departures from a strictly annual rate were found, and the additional fact that the scale reader would not ordinarily be in position to detect those departures, tends to limit the confidence which can properly be placed in any single reading. Adding greatly to the difficulty of scale reading is the imprecise manner in which many of the rings are formed. Age determination in the white crappie is not

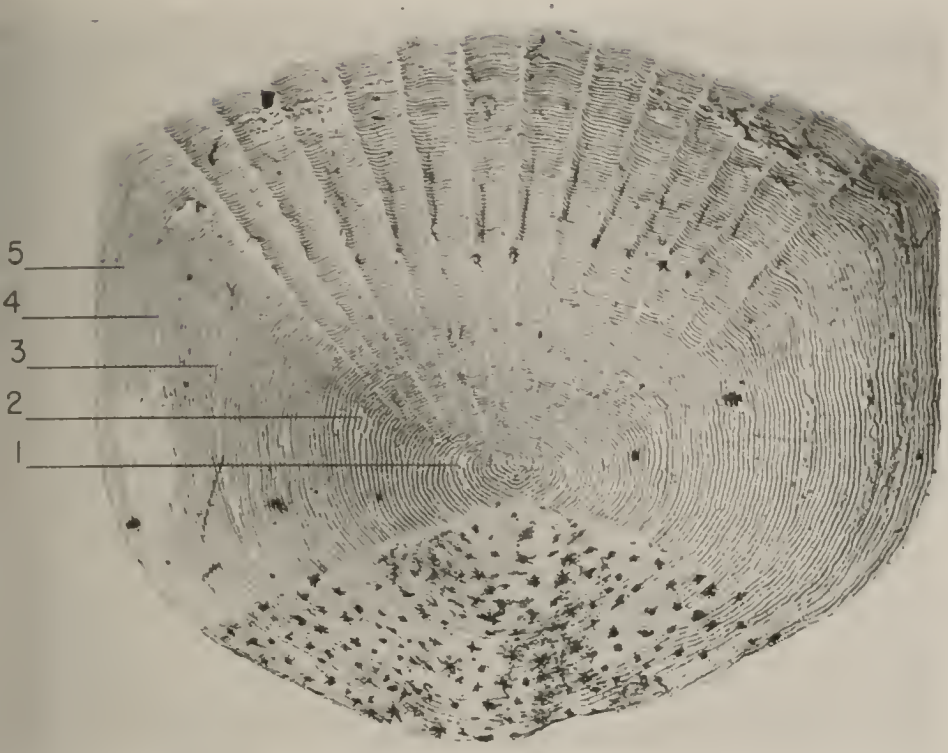

Fig. 9.—Scale from a white crappie that measured 10.1 inches when captured from the Rock River at Lyndon, Illinois, March 14, 1931. Cutting-over is unusually conspicuous in one of the lateral fields of annulus 3. The annulus or annual ring (five annuli are shown in the scale pictured) is a mark separating successive zones of annual growth. It makes its appearance on the scale when the fish begins a new season of growth rather than at the termination of a season of growth. The successive dark lines between the annuli represent ridges termed circuli. The distances between adjacent annuli are approximately proportional to growth increments of the fish in the years represented. The fish from which this scale was taken was not of known age, but its age is estimated to have been about 5½ years. Its age was greater than that of most crappies taken from Illinois waters. Relatively few crappies live longer than 3 or 4 years.

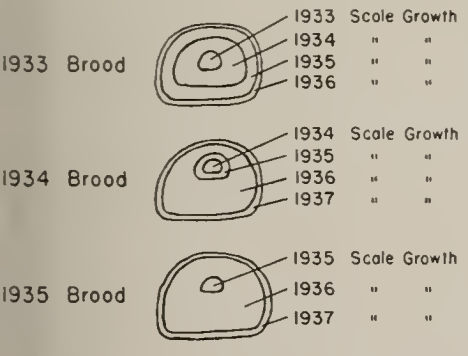

Fig. 10.—Annual ring patterns, that is, ring spacing, of white crappie broods hatched at Lake Decatur in the years 1933, 1934, and 1935. These ring patterns served to make individuals of the broods recognizable in later years.

a simple process of counting clearly defined marks of uniform appearance but instead is one which usually involves picking the true marks from an assortment which, to the scale reader, may seem to include some true rings, some false rings, and some rings which might be either one or the other.

Because of these several possible sources of error in aging white crappies through scale reading, the handling of the scale reading for the present paper needs explanation. Reading was carried on from the point of view that the scale method of aging fish should be used even though in many instances the age read might be only an approximation of the true age. However, it is believed that in only relatively

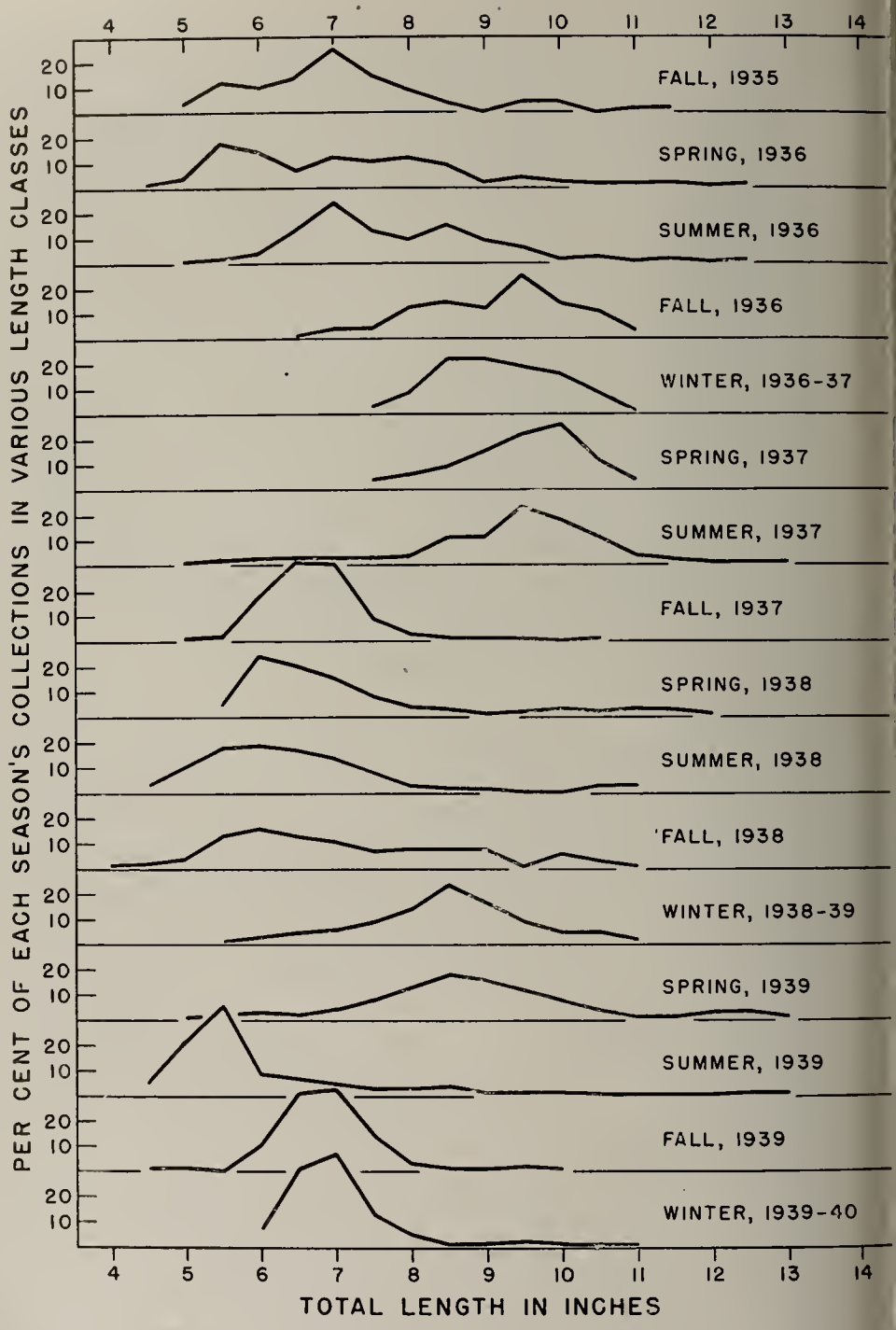

Fig. 11.—Length-frequency distribution (by half-inch classes) of Lake Decatur white crappies collected during the period 1935–1940. (Data from table 19. Some seasons omitted from graph because of meager data.)

few cases of age approximation did the age read deviate from the true age by more than a year.

Few scales were discarded for lack of their easy readability. If, on an individual scale, a ring was present that was believed to be false, the ring was omitted from the count. Conversely, a ring was sometimes counted, though imperfectly shown, or even entirely lacking, if supplementary information, such as length of fish, indicated that it should have been present. However, no addition was made to the count in the case of an unformed ring of the current year in a fish collected within the period of annulus formation.

The lack of a thoroughgoing study of age reading in crappies of positively known ages means that it is not yet possible to judge the success with which ages usually have been puzzled out or to appraise the effect of errors introduced either by faulty ring formation or faulty scale reading.

The Lake Decatur white crappie scales studied intensively for several years were usually more easily understood and probably read with a greater degree of accuracy than the scales from other places in the state. Favoring accurate determinations in the Lake Decatur scales were wide fluctuations in annual growth, which produced ring spacing patterns that were generally diagnostic for the various broods. Fig. 10 shows these patterns in three broods. Two later broods were separated on a length basis.

Size and Age Distribution

The size distribution in net catches of white crappies at Lake Decatur changed considerably from year to year, table 19 and fig. 11. Catches in some years included many large crappies; in other years mostly small. Moderate to large sizes, 8 to 11 inches, were prevalent in the nets at two periods (in alternate years) during the 4 years of study: from the fall of 1936 to the summer of 1937 and from the fall of 1938 to the spring of 1939. Occasional

Table 19.—Length distribution of white crappies caught in hoop nets at Lake Decatur; collections are grouped according to 3-month periods—spring: March, April, May; summer: June, July, August; fall: September, October, November; and winter: December, January, February. The same data expressed as percentages are plotted in fig. 11.

Total Length, Inches*	Fall, 1935	Spring, 1936	Summer, 1936	Fall, 1936	Winter, 1936–37	Spring, 1937	Summer, 1937	Fall, 1937	Winter, 1937–38	Spring, 1938	Summer, 1938	Fall, 1938	Winter, 1938–39	Spring, 1939	Summer, 1939	Fall, 1939	Winter, 1939–40
4	—	—	—	—	—	—	—	—	—	1	—	1	—	—	1	—	—
4½	—	3	—	2	—	—	—	—	1	1	3	3	—	1	33	3	1
5	2	17	1	1	—	—	6	2	—	1	12	5	—	6	135	2	1
5½	9	78	4	—	—	—	9	9	—	22	21	19	2	12	225	1	3
6	8	65	7	1	—	1	18	70	1	79	22	23	4	15	54	27	58
6½	11	29	25	2	—	2	17	125	7	67	20	18	8	13	43	83	260
7	18	53	47	12	1	2	16	121	4	51	16	15	9	21	33	90	298
7½	12	41	26	14	8	17	16	35	—	25	9	10	14	44	20	39	102
8	7	52	18	40	22	28	24	10	—	14	3	12	21	77	21	7	40
8½	3	40	30	45	66	40	58	3	—	8	2	11	37	106	24	3	11
9	—	10	17	39	66	70	57	4	—	3	2	11	26	93	7	3	11
9½	3	19	12	80	57	101	122	4	1	7	—	1	14	67	5	4	17
10	3	9	2	44	148	117	95	1	—	11	—	8	7	45	4	2	7
10½	—	4	4	36	22	55	59	3	—	7	3	4	8	25	1	1	4
11	1	3	—	9	4	17	21	—	2	9	3	2	3	7	1	—	4
11½	1	3	2	1	—	2	9	1	—	8	—	—	—	7	2	—	—
12	—	—	—	—	—	—	4	—	2	4	—	—	—	15	—	—	—
12½	—	2	2	—	—	1	4	—	—	—	—	—	—	16	6	1	—
13	—	—	—	—	—	1	4	—	—	—	—	—	—	7	4	—	—
13½	—	—	—	—	—	—	2	—	—	1	—	—	—	2	—	—	—
14	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Total	*78*	*428*	*197*	*326*	*294*	*454*	*541*	*388*	*18*	*320*	*116*	*143*	*153*	*579*	*619*	*266*	*817*

* Class center; for example, the 6-inch class includes fish of 5.8 through 6.2 inches in length.

observations of fishermen's stringers showed that nets were good indicators of the sizes likely to be caught by anglers.

Changes in Size Distribution.—Three separate factors enter into the changes in size distribution in the net samples: (1) availability in summer of broods hatched in the previous year; (2) summer growth of individual fish; and (3) periodic large-scale, and somewhat sudden, natural mortality of large fish, leaving for a time mainly fish of small sizes. The removal of large crappies by anglers is believed to have been a minor factor contributing to the periodic scarcity of large fish in the net samples.

Conspicuous changes in size distribution in white crappie populations were observed by Thompson & Bennett (1938) in an Illinois lake and by Wickliff *et al.* (1944, 1946) in several Ohio lakes. Size distribution changes in a black crappie population were observed by Thompson (1941). Thompson suggested that a single successful brood of black crappies hatched at Senachwine Lake in 1 year was able to consume most of the young crappies hatched for 3 or 4 years thereafter. When this first brood reached an age of 4 or 5 years, its members were sufficiently reduced by mortality that another brood survived in abundance. There is no evi-

Table 20.—Number of white crappies of various broods taken in hoop-net catches and number caught per net-day at Lake Decatur.

Date of Collection[1]	Hoop-Net Days[2]	1933 Brood		1934 Brood		1935 Brood		1936 Brood		1937 Brood	
		Number	Number per Net-Day	Number	Number per Net-Day	Number	Number per Net-Day	Number	Number per Net-Day	Number	Number per Net-Day
1936											
April 3	16	152	9.7	168	10.5	—	—	—	—	—	—
May 4–6	4	18	4.5	44	11.0	—	—	—	—	—	—
May 29–June 4	7	59	8.3	24	3.4	—	—	—	—	—	—
July 3–5	6	5	8.3	36	6.0	—	—	—	—	—	—
July 31–Aug. 3	5	4	8.0	27	5.4	51	10.5	—	—	—	—
Sept. 8–14	6	2	0.3	11	1.8	14	2.3	—	—	—	—
Sept. 22	4	1	0.2	11	2.7	49	12.2	—	—	—	—
Oct. 24–27	12	17	1.4	139	11.6	69	5.7	—	—	—	—
Dec. 21	15	18	1.2	107	7.1	171	11.4	—	—	—	—
1937											
March 1–4	16	53	3.3	220	13.7	67	4.2	—	—	—	—
April 24	6	14	2.3	67	11.2	35	5.8	—	—	—	—
June 3–5	12	32	2.7	116	9.7	62	5.2	—	—	—	—
June 24	9	27	3.0	73	8.1	27	3.0	—	—	—	—
July 10–16	27	15	0.6	37	1.4	29	1.1	6	0.2	—	—
Aug. 6–14	30	2	0.1	8	0.3	13	0.4	45	1.5	—	—
Sept. 22	6	2	0.3	2	0.3	7	1.2	206	34.3	—	—
Nov. 3	6	0	—	2	0.3	3	0.5	165	27.5	—	—
1938											
Jan. 17–24	17	0	—	3	0.2	0	0.0	12	0.7	—	—
March 14	9	0	—	14	1.0	16	1.8	181	20.1	—	—
May 28	8	0	—	8	1.0	4	0.5	84	10.5	—	—
July 1–14	9	0	—	0	—	4	0.4	24	2.7		
Aug. 25	14	0	—	0	—	2	0.1	19	1.4	56	4.0
Oct. 6	10	0	—	0	—	0	—	9	0.9	59	5.9
Nov. 4–11	20	0	—	0	—	0	—	17	0.9	49	2.5
1939											
Jan. 9	12	0	—	0	—	0	—	71	5.9	77	6.4

[1] June 22, 1936, data omitted because of uncertainties in age determination.
[2] The number of hoop-net days was obtained by multiplying the number of nets by the number of (24-hour) days they were fished.

dence that one brood dominated later broods in this manner at Lake Decatur, where strong broods were produced each year.

Changes in Age Distribution.—The entry of young broods into the net samples and the dropping out of older ones at Lake Decatur is shown somewhat roughly in table 20 by changes in the rate of catch in nets. The relatively short life span of broods was an outstanding characteristic of the Lake Decatur white crappie population. Assuming that June 1 was the approximate hatching date for all broods, it may be determined from table 20 that the 1933 brood disappeared from the net samples at an age of about 4 years and 4 months, the 1934 brood at 4 years, and the 1935 brood at 3 years and 3 months. But each of these broods showed a major decline in numbers a full year preceding its final disappearance from the samples, table 20. Longer life spans were observed in some broods in Lake Decatur, table 24, and in a number of other localities, table 28. It may be noticed, however, that fish with more than three annual rings were frequently scarce in Illinois collections. The highest number of annual rings, observed among several thousand age readings, was eight, table 28.

Influence of Periodic High Mortality on Size and Age Distribution.—The sharp drop in summer netting rates, table 20, suggests that heavy mortality occurred at Lake Decatur in one or more broods during the summer months in 1936, 1937, and 1938. Most broods, however, showed a certain amount of recovery in rate of nettability from summer to winter, indicating that the depressed summer rates were, in part, the result of low efficiency of summer netting operations. There is no clear indication of high summer mortality in these broods during their second summer of life—the first summer of net capture.

Lack of age readings prevented inclusion of most of the 1939 catch figures in table 20. However, there is evidence of considerable summer mortality among large crappies in 1939 from the fact that fish of the larger sizes were relatively more abundant in the spring than in the other seasons of that year, table 19 and fig. 11.

Normal variations in net catches make it impossible to give the exact date of highest summer mortality. It is suspected that highest losses may have occurred in June or July when the older crappies were at the lowest point in the annual condition cycle, although inquiries among lake-shore residents failed to show that dead crappies were more abundant along shore in June or July than at other times of the year.

Annual Growth Period

The beginning of the annual growth period of white crappies is marked by formation of the annual ring or annulus, fig. 9. Data on the time of annulus formation in white crappies at Lake Decatur in 1935 and 1936 have been published (Hansen 1937). Data for 1937 and 1938 are given in tables 21 and 22. A summary of data for the 4 years is given in table 23. The method of determining the time of annulus formation in crappies of 1937 and 1938 collections was more precise than the method used with the 1935 and 1936 collections. Because of the distinctive ring patterns of most broods of Lake Decatur white crappies in 1937 and 1938 collections, fig. 10, individual fish were assigned to their respective broods. Scales were then examined for presence or absence of annuli of the current growing season and for marginal growth beyond the new annuli.

On the basis of these studies, it is apparent that some white crappies of Lake Decatur started their annual growth much earlier than others, as much as 6 weeks earlier in one season to 10 weeks earlier in another. Generally, small, sexually immature fish formed their annuli earlier than large, mature ones.

The end of the annual growth period is estimated from the data on average length of fish in the various age classes in successive summer, fall, and early winter collections, table 24. Judged by length observations in well-represented age classes —classes with one or two annual rings— the fish of most Lake Decatur broods stopped growing about the latter part of September. However, there is indication that members of some broods may have continued to grow, but at a very slow

rate, during the months of October and November.

For two reasons it is not possible to state with certainty when growth stopped completely. First, there were gaps of a month or more between collections. Second, the length averages calculated for some broods tended to be erratic; for in-

Table 21.—Data on annulus formation in white crappies at Lake Decatur in 1937.

Date of Collection	1935 Brood			1934 Brood			1933 Brood		
	Total Number Caught	Number Having the 1937 Annulus	Per Cent Having the 1937 Annulus	Total Number Caught	Number Having the 1937 Annulus	Per Cent Having the 1937 Annulus	Total Number Caught	Number Having the 1937 Annulus	Per Cent Having the 1937 Annulus
March 1–4	67	0	0.0	220	0	0.0	54	0	0.0
April 24	34	0	0.0	67	0	0.0	14	0	0.0
May 16	37	0	0.0	39	0	0.0	10	0	0.0
June 3–5	71	8	11.5	117	0	0.0	36	0	0.0
June 24	27	3	11.1	74	1	1.3	26	0	0.0
July 10–16	30	12	40.0	37	1	2.7	15	0	0.0
Aug. 6–14	15	15	100.0	9	8	89.0	1	1	100.0
Sept. 22	5	5*	100.0	2	2*	100.0	—	—	—
Nov. 3	2	2*	100.0	2	2	100.0	—	—	—

* One of these fish showed an incomplete stage of annulus formation where new circuli were present on some of the scales but not others, or where new circuli were present only in certain areas of some scales.

Table 22.—Data on annulus formation in white crappies at Lake Decatur in 1938.

Date of Collection	1936 Brood			1935 Brood			1934 Brood		
	Total Number Caught	Number Having the 1938 Annulus	Per Cent Having the 1938 Annulus	Total Number Caught	Number Having the 1938 Annulus	Per Cent Having the 1938 Annulus	Total Number Caught	Number Having the 1938 Annulus	Per Cent Having the 1938 Annulus
March 14	—	—	—	12	0	0.0	13	0	0.0
May 28	69	0	0.0	5	0	0.0	5	0	0.0
July 1	4	2	50.0	2	0	0.0	2	0	0.0
July 14	24	6	25.0	—	—	—	1	0	0.0
Aug. 25	18	18*	100.0	2	1	50.0	1	1	100.0
Oct. 6	—	—	—	2	2	100.0	—	—	—
Nov. 4–11	—	—	—	4	4	100.0	1	1	100.0

* One of these fish had the annulus on only a part of its scales; of those scales which did not have the annulus some showed absorption and some did not.

Table 23.—Approximate periods of annulus formation in white crappies at Lake Decatur 1935–1938.

Year of Observation	Approximate Dates of Annulus Formation*	Approximate Length of Period
1935	Early May to early July or later	2 months or longer
1936	Early May to early July	1½ to 2 months
1937	Mid-May to early August or later	2½ months or longer
1938	Early June to late August or later	2½ months or longer

* The term "or later" is added when some individuals had still not formed the annulus at the approximate end of the period.

with a like number of visible rings). Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	NUMBER OF FISH	ANNUAL RING CLASS						
		0[1]	1	2	3	4	5	6
1935								
Nov. 22	78	—	6.5 (47)	7.9 (29)	11.4 (2)	—	—	—
1936								
April 3	324	—	6.0 (165)	7.9 (152)	10.2 (3)	10.4 (2)	9.8 (2)	—
May 4–6	75	—	6.1 (44)	8.1 (27)	11.5 (2)	12.4 (1)	11.7 (1)	—
May 29–June 4	100	—	6.9 (14)	8.1 (76)	10.9 (6)	12.0 (1)	11.7 (3)	—
July 3–5	45	—	6.8 (3)	7.7 (37)	8.1 (5)	—	—	—
July 31–Aug. 3	73	—	6.6 (51)	8.4 (19)	8.8 (3)	—	—	—
Sept. 22	61	—	8.1 (49)	9.3 (11)	9.6 (1)	—	—	—
Oct. 24–27	237	—	8.6 (71)	9.8 (149)	10.1 (17)	—	—	—
Dec. 21	297	4.5 (1)	8.7 (170)	9.9 (107)	9.9 (18)	9.8 (1)	—	—
1937								
March 1–4	346	—	8.6 (67)	9.6 (220)	9.9 (54)	10.7 (2)	12.8 (2)	11.7 (1)
April 24	117	—	8.6 (36)	9.8 (67)	10.1 (14)	—	—	—
May 16	86[2]	—	8.9 (37)	10.0 (39)	10.0 (10)	—	—	—
June 3–5	233	—	8.4 (63)	9.6 (125)	10.3 (37)	11.7 (4)	12.0 (3)	11.5 (1)
June 24	140	—	8.2 (28)	9.6 (76)	10.5 (27)	12.1 (3)	12.7 (5)	11.7 (1)
July 10–16	94	—	7.6 (25)	9.5 (48)	9.8 (16)	12.1 (4)	—	12.1 (1)
Aug. 6–14	74	—	6.4 (47)	8.7 (17)	10.2 (8)	10.4 (2)	—	—
Sept. 22	218	—	6.8 (207)	8.7 (7)	9.0 (2)	10.4 (2)	—	—
Nov. 3	170	—	6.5 (165)	9.2 (3)	10.3 (2)	—	—	—
1938								
Jan. 17–24	18	4.3 (1)	6.6 (12)	—	11.5 (3)	10.8 (2)	—	—
March 14	212	4.3 (2)	6.8 (179)	9.9 (16)	10.3 (14)	—	14.0 (1)	—
May 28	108	—	6.3 (86)	9.4 (5)	11.0 (12)	11.4 (4)	—	13.4 (1)
July 1	8	—	5.8 (2)	9.3 (6)	—	—	—	—
July 14[3]	29	—	5.7 (22)	6.0 (6)	11.1 (1)	—	—	—
Aug. 25	79	—	6.0 (58)	7.6 (19)	10.7 (2)	—	—	—
Oct. 6	67	—	7.5 (57)	8.9 (9)	10.3 (1)	—	—	—
Nov. 4–11	59	3.8 (1)	7.7 (44)	9.5 (10)	10.9 (2)	10.1 (1)	12.2 (1)	—
1939								
Jan. 9	159	4.1 (5)	7.7 (77)	9.0 (71)	10.5 (2)	10.9 (3)	—	13.0 (1)

[1] Only the largest representatives of the 0 group were caught in 1-inch-mesh nets.
[2] Caught by anglers.
[3] About six more large crappies, 10 to 11 inches long, were discarded without being measured or scales being taken.

stance, in 1937 collections, table 24, fish with one scale ring showed greater average length in September than in November.

Taking into account known individual differences in the beginning of the growing period and the uncertainties as to the end of the period, and ignoring any small growth which may have occurred in November, it may be estimated that the longest period of growth of any individual in any year was between 5 and 6 months, May 1 to September 30 or May 1 to October 31. It is almost certain, however, that in some years no individual grew for more than 4 months, that is, from June 1 to September 30. Since small, immature fish began growing earlier in the year than the spawners, the small fish probably grew for a longer period than the large fish.

The period of growth obviously was much less than 4 months for those white crappies that formed their annuli between the middle of July and the latter part of August. In 1937 the majority of individuals began their growth some time between the collecting dates of July 10 and August 14, and in 1938 between July 14 and August 25. The total growth period for these fish could not have been longer than 2 or 3 months. In 1935 and again in 1937 occasional individuals did not grow at all, and it is conceivable that some others may have started to grow as late as September or October and may have grown for less than a month.

Crappies of the 1934 brood seined from a Sangamon River overflow during the high water of 1935 had made little progress on their second year's growth when they were taken in June and early July, table 27.

Jones (1941) observed that largemouth and smallmouth bass in Norris Reservoir, Tennessee, grew for 4 months in 1939. In the same locality in 1940, Eschmeyer & Jones (1941) found that black crappies grew for about 5 months and that largemouth, smallmouth, and Kentucky bass grew for about 5 or 6 months. These writers did not record that individuals began growth at widely different times.

Growth Rates

White crappie growth rates were found to vary in different waters of the state

Table 25.—Average observed total lengths, in inches, of Lake Decatur white crappies of various ring classes at time of hoop-net capture between growing seasons. Data from table 24. Figures in parentheses represent numbers of specimens.

Date of Collection	Annual Ring Class					
	1	2	3	4	5	6
Nov. 22, 1935	6.5 (47)	7.9 (29)	11.4 (2)	—	—	—
April 3, 1936	6.0 (165)	7.9 (152)	10.2 (3)	10.4 (2)	9.8 (2)	—
Average	***6.1*** (212)	***7.9*** (181)	***10.7*** (5)	***10.4*** (2)	***9.8*** (2)	—
Dec. 21, 1936	8.7 (170)	9.9 (107)	9.9 (18)	9.8 (1)	—	—
March 1–4, 1937	8.6 (67)	9.6 (220)	9.9 (54)	10.7 (2)	12.8 (2)	11.7 (1)
April 24, 1937	8.6 (36)	9.8 (67)	10.1 (14)	—	—	—
Average	***8.7*** (273)	***9.7*** (394)	***9.9*** (86)	***10.4*** (3)	***12.8*** (2)	***11.7*** (1)
Nov. 3, 1937	6.5 (165)	9.2 (3)	10.3 (2)	—	—	—
Jan. 17–24, 1938	6.6 (12)	—	11.5 (3)	10.8 (2)	—	—
March 14, 1938	6.8 (179)	9.9 (16)	10.3 (14)	—	14.0 (1)	—
Average	***6.7*** (356)	***9.8*** (19)	***10.5*** (19)	***10.8*** (2)	***14.0*** (1)	—
Nov. 4–11, 1938	7.7 (44)	9.5 (10)	10.9 (2)	10.1 (1)	12.2 (1)	—
Jan. 9, 1939	7.7 (77)	9.0 (71)	10.5 (2)	10.9 (3)	—	13.0 (1)
Average	***7.7*** (121)	***9.1*** (81)	***10.7*** (4)	***10.7*** (4)	***12.2*** (1)	***13.0*** (1)
Grand average	*7.3*	*9.1*	*10.5*	*10.6*	*12.2*	*12.3*

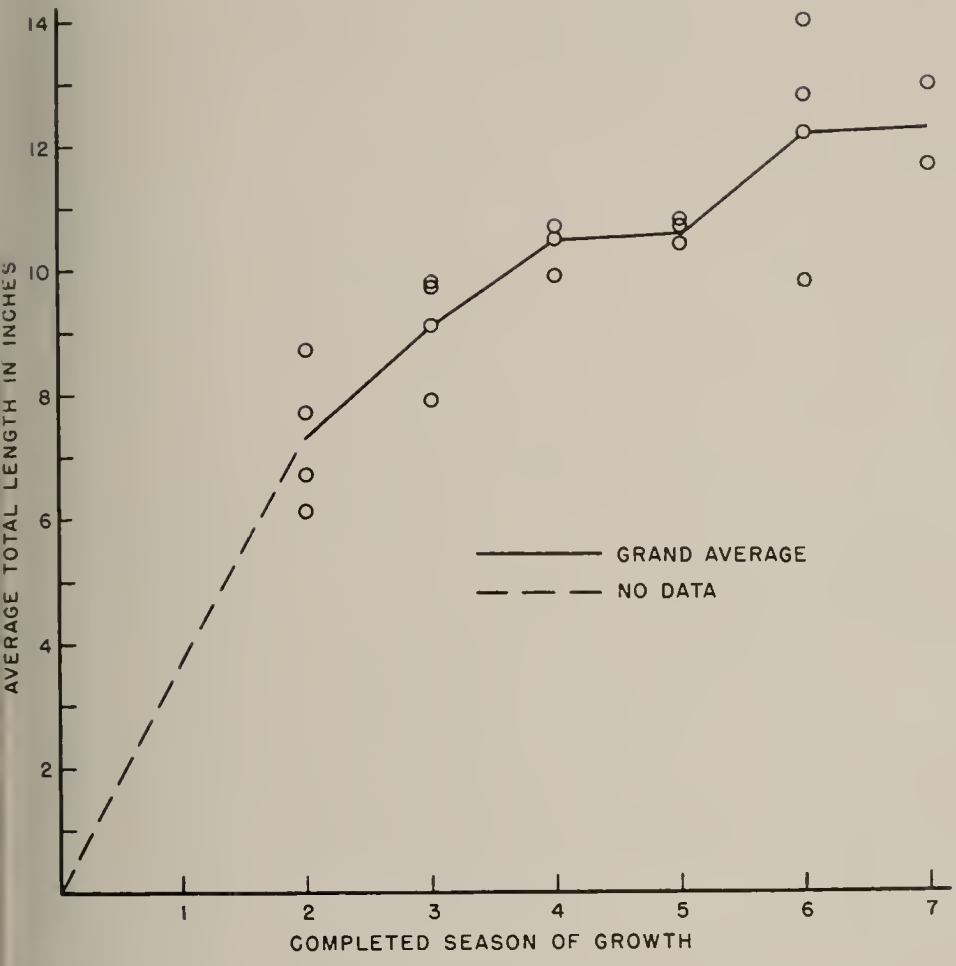

Fig. 12.—Observed average total lengths of Lake Decatur white crappies at end of various completed growing seasons. Each circle shows the average length of individuals of the same age found in winter collections of different calendar years. Sizes of crappies at end of first growing season are not shown, as fish were then too small to be taken in nets.

and from year to year in the same water—notably in Lake Decatur.

Growth Rates at Lake Decatur.—At the time of this study the average growth rate of the white crappies of Lake Decatur, as shown at the bottom of table 25, was probably equal to, if not faster than, the average rate for this species in other waters of the state, table 28.

The tendency toward rapid growth of the Lake Decatur white crappies means that, even though fish of large sizes were periodically almost wiped out by high mortality, rapid growth of the surviving younger fish resulted in a new supply of large fish within about a year of the time when scarcity of large fish set in.

Growth of fish in the second and third years of life varied from good to poor, but poor growth was not seen in any one brood for 2 years in succession, and in all broods fish reached an average length of about 8 inches or more within their first three growing seasons.

Average sizes of Lake Decatur white crappies of six annual ring classes are shown in table 25 and fig. 12. Fish were placed in a given annual ring class in accordance with the scale reading practices described in the section "Age Determina-

Table 26.—Average observed total lengths, in inches, of Lake Decatur white crappie males and females. Figures in parentheses represent numbers of specimens.

Date of Collection	Annual Ring Class											
	1		2		3		4		5		6	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
1936												
July 31–Aug. 3.	6.6 (27)	6.5 (24)	8.4 (14)	8.4 (13)	8.8 (2)	9.2 (2)	—	—	—	—	—	—
Sept. 8–22.....	8.1 (37)	7.7 (25)	9.2 (14)	9.4 (9)	9.6 (1)	9.5 (2)	—	—	—	—	—	—
Oct. 24–27.....	8.6 (42)	8.6 (25)	9 9 (70)	9.8 (74)	9.2 (7)	10.8 (10)	—	—	—	—	—	—
Dec. 21.....	8.7 (96)	8.7 (76)	9.8 (51)	9.9 (54)	9.4 (6)	10.0 (12)	—	—	—	—	—	—
1937												
March 1–4.....	8.6 (34)	8.4 (18)	9.6 (96)	9.8 (98)	9.8 (19)	10.1 (28)	9.8 (1)	11.3 (1)	—	12.5 (1)	—	11.7 (1)
April 24.....	8.8 (15)	8.7 (19)	9.6 (22)	9.8 (45)	10.4 (4)	10.1 (10)	—	—	—	—	—	—
June 3–5.....	8 6 (34)	8.6 (25)	9.6 (45)	9.4 (44)	10 1 (10)	10.4 (25)	—	11.7 (4)	—	12.0 (3)	11.5 (1)	—
June 24.....	8 8 (16)	8.6 (8)	9.5 (30)	9.8 (45)	10.4 (6)	10.5 (19)	—	12.1 (3)	—	12.9 (5)	—	11.7 (1)
1938												
Nov. 4–11.....	7.8 (27)	7.6 (22)	9.8 (5)	9.2 (12)	10.4 (3)	10.8 (1)	10.1 (1)	—	12.2 (1)	9.2 (1)	—	—
1939												
Jan. 9.....	7.8 (51)	7.5 (26)	9 3 (33)	8.9 (38)	10.8 (1)	10.3 (1)	10.8 (2)	11.3 (1)	—	—	—	—
Average.....	*8.3* (379)	*8.2* (268)	*9.6* (380)	*9.6* (432)	*9.9* (59)	*10.3* (110)	*10.4* (4)	*11.7* (9)	*12.2* (1)	*12.0* (10)	*11.5* (1)	*11.7* (2)

Table 27.—Average size of white crappies after approximately one season of growth, based on direct observation of young fish. In the estimation of age it was assumed that the fish were spawned about June 1.

Body of Water	Date of Observation	Number of Specimens	Approximate Age, Months	Average Total Length, Inches
Buck's Pond, Monticello	Oct. 6, 1938	115	4	2.6
Ortman's Lake, Crescent City	Oct. 19, 1933	37	4½	3.7
Lincoln Lakes, Lincoln	May 20, 1938	17	12	3.7
Sangamon River overflow below Lake Decatur Dam	May 20–22, 1935	61	12	3.5
	June 26, 1935*	50	13	3.6
	July 11–16, 1935	96	13½	3.7

* The fish in this collection and the one following were a little more than a year old but making slow second-summer growth.

tion." For example, all fish having scales that the reader interpreted as having one ring were placed in annual ring class 1. The fish of that category represented in this table were believed to have completed two seasons of growth.

The data in table 25 were taken from table 24 and include only fish caught from early November to late April, a time of year when the fish were not growing in length (except perhaps at a very slow rate) and annual rings were not being formed.

Comparisons of the year-to-year growth of the Lake Decatur white crappies of various broods can be made by reading the boldface type in table 25 diagonally downward from left to right. For example, fish of the 1934 brood showed one scale ring and averaged 6.1 inches in the combined collections of November 22, 1935, and April 3, 1936. It is this same brood that showed two rings and averaged 9.7 inches a year later in the combined collections of December 21, 1936, March 1–4, and April 24, 1937.

Comparisons of the average lengths of the fish of different broods at the same attained ages can be made by reading the boldface type in table 25 vertically.

The year 1936 was an exceptionally good growing year at Lake Decatur, particularly for fish in the second and third years of life. The good growth of the 1934 brood in 1936 is shown in the figures cited above. Fish of the 1935 brood averaged 3.5 inches at the start of the 1936 growing season and reached a length of 8.7 inches at the end. (The length at the start of the season was computed from scale measurements; similar computation was not employed elsewhere in this paper.) The exceptionally good growth made by these broods in 1936 is believed to have resulted from heavy feeding on fingerling gizzard shad, *Dorosoma,* which were commonly seen in schools and were regularly found in crappie stomachs during the 1936 growing season. The very good growing season of 1936 came between two very poor growing seasons, 1935 and 1937.

In studies on other centrarchids by Hile (1931), Tester (1932), Hubbs & Cooper (1935), Bennett (1938), Schoffman (1938, 1939), and Bennett, Thompson, & Parr (1940), males and females showed very nearly the same rates of growth, or the males showed a tendency to grow slightly faster than the females. At Lake Decatur, among white crappies that were sexed, table 26, there were only small differences in average lengths of males and females of the same age, and such differences, seldom amounting to more than one-half inch, were not consistently in favor of either sex in the various collections.

Growth Rates in Other Illinois Waters.—Because white crappies are seldom caught in 1-inch-mesh hoop nets until they are 13 to 15 months old, the average size reached by these fish at the end of their first season has been determined by direct observation of young fish captured in four Illinois waters by means other than hoop nets, table 27. The Lincoln Lakes and Buck's Pond samples were taken by poisoning, the Ortman's Lake sample by draining, and the Sangamon River backwater samples by seining.

Table 28.—Average observed total lengths, in inches, of white crappies from various Illinois waters, the fish grouped according to annual ring classes. Figures in parentheses represent numbers of specimens. (Lake Decatur hoop-net collections, 1935–1939, shown in table 24).

Body of Water and Nearest Town	Date	Method of Collection[1]	Number of Specimens	Annual Ring Class							
				1	2	3	4	5	6	7	8
Illinois River and Oxbow Lakes											
Senachwine Lake, Henry	Aug. 18–31, 1933	1 inch H	70	6.3 (54)	7.3 (14)	8.1 (2)	—	—	—	—	—
	Sept. 1–29, 1933	1 inch H	115	6.5 (86)	8.7 (23)	8.9 (6)	—	—	—	—	—
	Oct. 2–13, 1933	1 inch H	80	6.5 (42)	8.3 (38)	—	—	—	—	—	—
	June 8–20, 1934	1 inch H	66	5.2 (15)	7.2 (49)	7.9 (2)	—	—	—	—	—
Clear Lake, Liverpool	Dec. 6–17, 1931	1 inch H & ?	26[2]	7.5 (9)	8.7 (12)	9.0 (4)	9.8 (1)	—	—	—	—
Lake Chautauqua, Havana	Sept. 1–9, 1936	1 inch H	196	6.9 (148)	6.9 (48)	—	—	—	—	—	—
	Nov. 13–14, 1936	1 inch H	78	7.9 (76)	8.2 (2)	—	—	—	—	—	—
River channel, Havana	Jan. 3, 1931	?	23[3]	—	7.8 (10)	8.1 (10)	8.2 (2)	7.5 (1)	—	—	—
	May 11, 1931	¼ inch S	18[3]	6.5 (4)	7.0 (8)	7.1 (6)	—	—	—	—	—
	June 9, 1931	¼ inch S	32[3]	5.3 (13)	6.0 (13)	6.5 (6)	—	—	—	—	—
Matanzas Lake, Havana	Feb. 16–March 4, 1931	1½ inch H	141[3]	6.8 (16)	8.6 (32)	9.3 (85)	9.5 (8)	—	—	—	—
Dierker Lake, Bath	Jan. 24, 1931	1½ inch H	15[3]	—	9.0 (4)	9.5 (10)	9.6 (1)	—	—	—	—
River channel, Bath	Nov. 4–19, 1931	1 inch H	143[3]	8.4 (80)	9.6 (46)	10.0 (15)	10.8 (2)	—	—	—	—
Stewart Lake, Browning	Nov. 5, 1931	1 inch H	15[3]	9.2 (7)	9.8 (7)	11.0 (1)	—	—	—	—	—
Meredosia Bay, Meredosia	June 21–29, 1927	1¼–1½ inch H	15	—	9.3 (9)	10.8 (6)	—	—	—	—	—
	June 23–29, 1931	1 inch H	79	5.7 (10)	6.9 (30)	9.2 (15)	9.3 (19)	9.3 (5)	—	—	—
	July 11–31, 1931	1 inch H	230	6.1 (21)	7.3 (20)	9.0 (44)	9.6 (122)	9.5 (22)	11.3 (1)	—	—
	Aug. 5–7, 1931	1 inch H	50	7.1 (1)	8.3 (8)	8.9 (23)	9.4 (15)	9.5 (3)	—	—	—
	May 18–29, 1934	1 inch H	46	7.8 (19)	9.2 (12)	10.3 (10)	11.3 (2)	11.1 (3)	—	—	—
Mississippi River and Oxbow Lakes											
River channel, Savanna	Sept. 1–7, 1932	1 inch S	27	—	7.6 (8)	7.8 (9)	8.3 (7)	8 7 (2)	8.9 (1)	—	—
River channel, Clinton, Iowa	Sept. 14–20, 1932	1 inch H	33	—	7.8 (22)	8.1 (9)	9.5 (1)	8.9 (1)	—	—	—
River channel, New Boston	Aug. 14–19, 1932	1 inch H & S	39	—	7.9 (9)	7.7 (14)	8.3 (9)	8.7 (5)	9.2 (1)	7 9 (1)	—
Horseshoe Lake, Cairo	March 16–24, 1936	1 inch H	52	7.0 (4)	9.6 (7)	11.3 (36)	14.6 (4)	13.1 (1)	—	—	—
	April 8, 1937	1 inch H	94	7.5 (39)	9.0 (2)	12.1 (10)	13.6 (38)	13.1 (3)	13.3 (1)	13.1 (1)	—
	Feb. 19–27, 1938	1 inch H	178	7.1 (81)	8.7 (71)	12.6 (3)	12.1 (8)	13.9 (15)	—	—	—
	May 7, 1938	1 inch H	47	7.2 (17)	8.2 (20)	8.7 (1)	13.3 (2)	14.1 (5)	14.2 (1)	14.9 (1)	—
	April 19, 1941	2½ inch H	33[2]	—	—	12.9 (2)	12.8 (9)	14.1 (17)	13.1 (1)	15.9 (3)	15.5 (1)
Fox River											
River channel, 1–3 mi. above Grass Lake, Spring Grove	July 10–14, 1930	1½ inch H	17	—	—	8.3 (6)	9.3 (9)	10.3 (2)	—	—	—
River channel, McHenry	July 16–Aug. 1, 1930	1 inch H & S	45	5.1 (3)	7.0 (14)	8.8 (21)	9.8 (6)	8.9 (1)	—	—	—
River channel, above St. Charles dam	Aug. 21, 1930	1 inch H & S	22	5.8 (2)	7.8 (14)	9.8 (3)	10.5 (3)				

Sterling pool, Nelson	Nov. 6, 1934	1 inch H	10	—	8 7 (4)	10.8 (4)	11 5 (2)				
Sterling pool, Sterling	April 21, 1938	1 inch H	13	7 9 (9)	8 9 (3)	9 5 (1)	—				
Kaskaskia River											
River channel, Sullivan to Carlyle	Aug. 1–23, 1929	1 inch H	55	6.3 (1)	7 1 (34)	8.1 (16)	7 9 (4)	—	—	—	—
Ohio River and Oxbow Lakes											
River channel, Shawneetown	May 1–21, 1935	1 inch H	197	5 4 (2)	7 0 (84)	7.5 (101)	9 0 (10)	—	—	—	—
Allard Lake, Brookport	March 29–April 4, 1930	1¼ inch H	68[3]	—	8.6 (39)	9 3 (23)	9 9 (6)	—	—	—	—
Kinneman Lake, Brookport	April 12–18, 1930	1½ inch H	64	—	8.7 (11)	9 8 (28)	11 9 (13)	11 8 (10)	11 8 (2)	—	—
Lower Saline River and tributaries											
Shawneetown	June 5–12, 1935	1 inch H	18	6.9 (1)	8 2 (6)	9 0 (7)	9 9 (3)	—	11 4 (1)	—	—
Sangamon River											
River channel, Mahomet	June 11–24, 1933	1 6 inch S	33	6 3 (15)	6 8 (15)	6.9 (3)	—	—	—	—	—
	July 7–24, 1933	1 6 inch S	66	6.3 (18)	6.4 (34)	7 0 (14)	—	—	—	—	—
	Aug. 2–18, 1933	1 6 inch S	35	6.0 (16)	6 1 (18)	7 3 (1)	—	—	—	—	—
	Sept. 7–21, 1933	1 6 inch S	48	6 0 (16)	6.5 (31)	7 6 (1)	—	—	—	—	—
River channel, Monticello	July 12–13, 1929	1 inch H	19	—	6 6 (13)	6.0 (5)	8 6 (1)	—	—	—	—
River channel, Decatur	May 17, 1935	A	33	7.9 (23)	7.7 (7)	9 4 (3)	—	—	—	—	—
	June 25–26, 1935	A	108	6.4 (49)	6.9 (51)	7.0 (4)	9 3 (2)	8 1 (2)	—	—	—
	July 11–16, 1935	A	192	6 8 (77)	7.0 (104)	9 4 (9)	8 4 (2)	—	—	—	—
Miscellaneous Lakes											
Maple Lake, Willow Springs	Aug. 10–31, 1937	1 inch H	84	6.6 (7)	7 8 (64)	8.7 (11)	8 8 (2)	—	—	—	—
Lake Bloomington, Bloomington	Sept. 10, 1937	1 inch H	49	6 4 (17)	7 1 (15)	7 5 (17)	—	—	—	—	—
Lincoln Lakes, Lincoln	June 15, 1937	A	34	5.5 (1)	6 9 (5)	6.5 (27)	9 5 (1)	—	—	—	—
	May 20, 1938	P	146	5.6 (45)	6.3 (58)	6 6 (3)	7.0 (40)	—	—	—	—
Weldon Springs Lake, Weldon	July 7, 1936	1 inch S	28	—	7.2 (4)	7 6 (20)	8 4 (4)	—	—	—	—
	Sept. 6, 1938	P	115	5 4 (49)	6.1 (64)	6.1 (1)	—	—	12 8 (1)	—	—
Homewood Lake, Decatur	April 12, 1938	1 inch H	88	6.3 (33)	7 1 (28)	7.2 (23)	7.3 (3)	6.8 (1)	—	—	—
	June 16–29, 1938	1 inch H	87	5.7 (8)	6.4 (52)	7 1 (21)	6.9 (6)	—	—	—	—
	July 21, 1938	P	47	—	6 4 (36)	6 9 (9)	7.3 (2)	—	—	—	—
Mattoon Lake, Mattoon	March 12–14, 1931	1 inch S	18[4]	6.5 (3)	8.4 (5)	8 7 (6)	9.6 (2)	12 8 (1)	15 4 (1)	—	—
Pollywogs, Danville	Feb. 28, 1931	1 inch H	12[3]	—	9.9 (7)	9 6 (2)	8 9 (1)	9 9 (1)	11 0 (1)	—	—
	Dec. 26, 1931–April 9, 1932	1 inch H	30[3]	9.5 (1)	9 4 (27)	10.3 (2)	—	—	—	—	—

[1] Method of collection: A—Angling, H—hoop net, S—seine, P—introduced poison (rotenone), H & S—hoop net and seine, H & ?—hoop net and unspecified devices, ?—unspecified devices. Mesh sizes refer to bar or square measure in inches. The mesh size of a hoop net is given only for the pot of the net.

[2] Extent of selectivity not known.

[3] Not a random sample. In most of these selective samples, scales were not taken from individuals under about 6 inches total length.

[4] Probably not a random sample, but all sizes represented to some extent.

Table 29.—Selected examples of rapid growth and slow growth in Illinois white crappies. Observed total lengths in inches. (Data from tables 24 and 28.) Figures in parentheses represent numbers of specimens.

Body of Water and Nearest Town	Date of Collection	Annual Ring Class						
		1	2	3	4	5	6	7
(Populations Exhibiting Rapid Growth)								
Horseshoe Lake, Cairo	April 8, 1937	7.5 (39)	9.0 (2)	12.1 (10)	13.6 (38)	13.1 (3)	13.3 (1)	13.1 (1)
Lake Decatur, Decatur	March 14, 1938	6.8 (179)	9.9 (16)	10.3 (14)	—	14.0 (1)	—	—
Kinneman Lake, Brookport	April 12–18, 1930	—	8.7 (11)	9.8 (28)	11.9 (13)	11.8 (10)	11.8 (2)	—
Meredosia Bay, Meredosia	May 18–29, 1934	7.8 (19)	9.2 (12)	10.3 (10)	11.3 (2)	11.1 (3)	—	—
Illinois River channel, Bath	Nov. 4–19, 1931	8.4 (80)	9.6 (46)	10.0 (15)	10.8 (2)	—	—	—
(Populations Exhibiting Slow Growth)								
Weldon Springs Lake, Weldon	Sept. 6, 1938	5.4 (49)	6.1 (64)	6.1 (1)	—	—	12.8 (1)	—
Lincoln Lakes, Lincoln	May 20, 1938	5.6 (45)	6.3 (58)	6.6 (3)	7.0 (40)	—	—	—
Homewood Lake, Decatur	April 12, 1938	6 3 (33)	7.1 (28)	7.2 (23)	7.3 (3)	6.8 (1)	—	—
Ohio River, Shawneetown	May 1–21, 1935	5.4 (2)	7.0 (84)	7 5 (101)	9.0 (10)	—	—	—
Sangamon River, Mahomet	Sept. 7–21, 1933	6.0 (16)	6.5 (31)	7.6 (1)	—	—	—	—
Kaskaskia River, Sullivan to Carlyle	Aug. 1–23, 1929	6.3 (1)	7.1 (34)	8.1 (16)	7.9 (4)	—	—	—

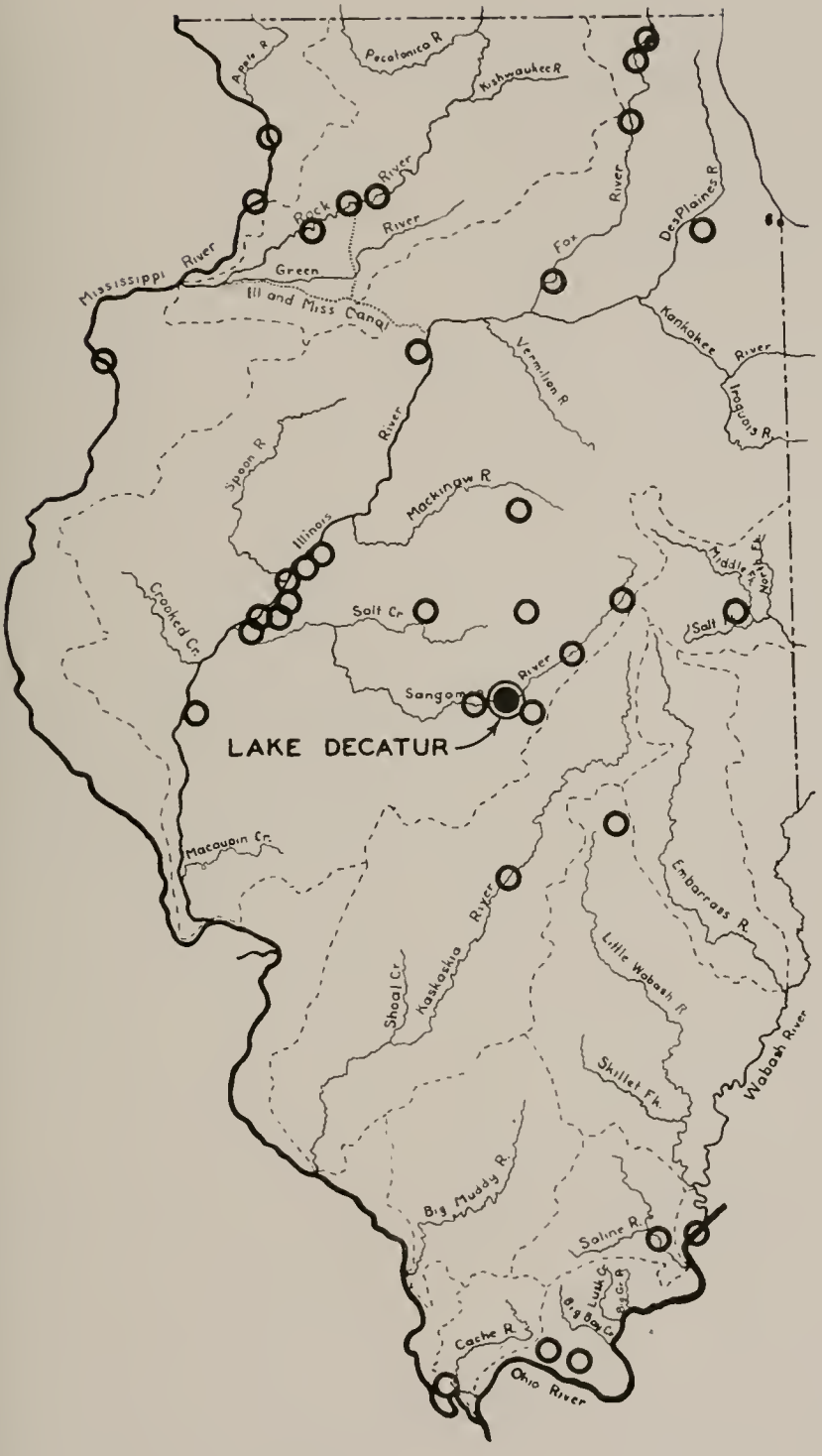

Fig. 13.—Illinois localities represented by age determinations of fish included in table 28.

In Illinois waters other than Lake Decatur, study of growth in fish more than a year old was based on scale samples from lakes or streams in 33 localities in widely scattered sections of the state, fig. 13. Lengths of fish having a like number of annual rings were averaged for each collecting period at each locality, table 28.

Table 28 shows wide differences in sizes of fish having a like number of annual rings. Some of these averages are not subject to direct comparison, since small fish in the samples were not always adequately represented. Especially was this true in several samples collected in 1931 and before (footnote 3, table 28). Some collections were made during the active growing period of the fish collected, while others were made between growing periods. In the case of summer collections, it was not known whether the outer ring on a scale was the ring of the current year or of the preceding year.

Data on some of the outstanding examples of white crappie populations containing fast-growing and slow-growing fish are recorded in table 29. Populations containing slow-growing fish like those found in Weldon Springs, Lincoln, and Homewood lakes are termed "stunted." Such populations contain only a small percentage of crappies over 8 inches in length even though a large percentage are 3 to 5 years old. Growth in these populations is not so abnormally slow during the first 2 years as during the third year and later.

Of all Illinois waters sampled, Horseshoe Lake, in Alexander County, contained the largest white crappies. In this lake, annual growth increments were especially large among fish that had lived beyond the third year. Also, the rate of survival of fish beyond the fourth year appears to have been exceptionally high. The Horseshoe Lake population has been analyzed previously by Thompson & Bennett (1938). Probably the good growth observed in this lake was due to the recent origin of the population. The lake was drained in 1930 and refilled and restocked in 1931.

Lake Decatur, where growth was rapid, and Homewood, where growth was slow, table 29, are in the same central Illinois locality; Homewood Lake was formed by damming one of the small valleys tributary to Lake Decatur.

Growth Rates in Out-of-State Waters.—Growth of the white crappie has been studied in three neighboring states: at Reelfoot Lake, Tennessee, by Schoffman (1940); at Lake of the Ozarks, Missouri, by Weyer (1940); in Indiana lakes by Ricker & Lagler (1942), and Johnson (1945); and in three TVA reservoirs, two in Tennessee and one in North Carolina, by Stroud (1949). The growth rates observed in these bodies of water fall approximately in the range observed in Illinois waters.

Eschmeyer & Jones (1941) found that in the early years of impoundment of Norris Reservoir, the black crappies there grew at a much faster rate than has yet been observed in Illinois white crappies. The first brood of black crappies hatched in Norris Reservoir (in 1937) averaged 11.5 inches (total length) when they had completed two summers of growth. (The best recorded growth for an adequate sample of Illinois white crappies with two completed summers was found at Lake Decatur in the winter collections of 1936–37. The fish of these collections averaged 8.6 inches in length.) The third brood of black crappies hatched at Norris Reservoir (in 1939) grew at about the same rate in their first summer as Illinois white crappies of the same age, but the rate of growth in their second year, when they reached 8.9 inches, was faster than the best average for Lake Decatur.

Eschmeyer & Jones (1941) attributed the good growth in the early years at Norris Reservoir to abnormal richness of the lake in basic food elements and lack of severe competition.

SUMMARY

This paper is based primarily on an intensive study of the white crappie in Lake Decatur, Macon County, Illinois, where sampling was carried on at 1- to 2-month intervals the year round from late 1935 to late 1939. It is based in part on additional information obtained from various fisheries investigations carried on by members of the aquatic biology staff of the Natural History Survey during an 18-year period beginning in 1927.

The white crappie and the black crappie, both important as sport fishes in Illinois, are abundant throughout the state. The white crappie generally outnumbers the black in small streams or creeks and in artificial lakes of all sizes. The black tends to be the more common species in the deep glacial lakes of northeastern Illinois. In the larger rivers and in the bottomland lakes preponderance of one species over the other varies from lake to lake and from one part of the channel to another.

At the time of this study, fishermen used various methods of angling, some uncommon, and various kinds of baits in fishing for white crappies in Illinois. At Lake Decatur they caught white crappies principally from March 1 to June 1.

In year-round hoop-net fishing at Lake Decatur, the poorest catches were made in the summer.

White crappies require 2 years or, sometimes, 3 years to reach sexual maturity. The smallest ripe female observed in Illinois measured 5.6 inches total length. Dark breeding coloration was found in most males of breeding size from April to June (or July) and was seen in the female. Ripe females (with mature eggs) were found in Illinois as early as May 6 and as late as July 13; ripe males as early as May 16 and as late as June 4. The height of the Illinois spawning season is probably late May or early June. It appears that only a portion of the eggs in ripe females are laid and that perhaps a considerable number of unlaid eggs are absorbed.

Crappies spawn under a variety of conditions of bottom, water depth, and proximity to vegetation, embankments, and wooden structures. They seem to show a preference for depositing their eggs on plant material, but they do not require aquatic plants for that purpose.

Net samples showed a predominance of males among young white crappies, a predominance of females among older white crappies. They showed a temporary scarcity of males in late spring and early summer.

Lymphocystis, the most common disease observed in white crappies, was found in 9.5 per cent of the white crappies in one locality.

Comparisons in the relative plumpness of the members of different length classes and broods were based on the coefficient of condition, K. Small fish usually began their annual growth before large fish and showed earlier summer gains in condition. Large fish reached peak condition in late fall or early winter; small fish reached peak condition in midsummer. Small fish showed condition losses in late summer and additional losses in early spring. Large fish suffered condition losses mainly in spring and early summer.

At most times of the year the K values were higher in large white crappies than in small ones. Differences in K values were least apparent in June and July when the large fish were at the low point in the condition cycle and the small fish were nearing the top of the cycle. K values were approximately the same in males and females of the same size categories, irrespective of time of year.

Evidence obtained at Lake Decatur indicates that the annual rings on the scales of white crappies are not invariably formed at the rate of one ring for each year of life and that the rings are not formed at exactly the same time of year.

The sizes of white crappies caught in the nets at Lake Decatur fluctuated strongly from year to year. Large sizes were abundant only in alternate years. Disappearance of large sizes is believed to have been due to large-scale summer mortality (heavier some summers than others).

Lake Decatur crappie broods were generally short lived. Broods were usually not conspicuous in net catches beyond the second or third year of life. One brood disappeared completely at the age of 3 years and 3 months; another brood at 4 years and 4 months.

Dates of annulus formation were obtained for 4 consecutive years at Lake Decatur. Start of growth ranged from early May in some fish to late August or later in others.

The annual growth period at Lake Decatur varied for most individual fish from about 2 to 6 months. Some individuals failed to grow at all in 1935 and 1937.

The average observed lengths of white crappies falling into various annual ring classes were recorded for Lake Decatur

and 33 other Illinois localities. The annual growth increments of the white crappies at Lake Decatur varied widely from year to year. This was true particularly of fish in the second and third years of life, which grew exceptionally well in 1936 bu made little or no growth in 1935 and 193

Only small differences in the growt rates of males and females were foun among the white crappies of Lake Decatu

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